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A Preliminary Summary of

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Progress and Plans //

OCT 20 1964

C & R-PREP.

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VEGETABLE RESEARCH

of the United States Department of Agriculture
and

in cooperation with
State Agricultural Experiment Stations ; + 32

Prepared for the Department's
VEGETABLE RESEARCH AND MARKETING ADVISORY COMMITTEE

for its 15th Annual Meeting
Washington, D. C.
February 8-11, 1960

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This progress report is primarily a tool for use by advisory committee members in developing recommendations for present and future research programs and by USDA administrators for developing, coordinating, and evaluating research plans. Included in it are summaries of research done during the past year. Some are tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to advisory committee members, research administrators, and others having special interest in the development of public agricultural research programs.

The report also lists publications of research results issued during the year. Current agricultural research findings are also reported in the monthly USDA publications, "Agricultural Research" and "Agricultural Marketing."

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FUNCTIONS OF ADVISORY COMMITTEES

The Vegetable Committee is one of twenty-five commodity and functional committees of the U. S. Department of Agriculture established pursuant to Title III of the Research and Marketing Act of 1946. Functions of the members of these committees include:

1. Acquainting themselves with the problems of producers, processors, distributors, and consumers, and presenting them for committee consideration.
2. Reviewing the current research and marketing service programs of the Department and recommending adjustments, including terminations, in the current program in order that available funds, personnel, and facilities will be used on problems of greatest importance.
3. Recommending new work or expansion of current work and indicating relative priority of such recommendations, when the current program is insufficient to develop solutions for important problems.
4. Developing a better understanding of the nature and value of the agricultural research program, explaining it to interested groups and organizations and encouraging the wider and more rapid application of the findings of research.

The committees perform an important function in advising with respect to the development of the Department's research and marketing service programs. However, committee members recognize that the development of budgets and the implementation and administration of research and marketing programs are responsibilities of the Department.

A progress report similar to this one is prepared for each committee. The areas of the other twenty-four committees are:

Citrus and Subtropical Fruit	Livestock
Cotton and Cottonseed	Oilseeds and Peanut
Dairy	Potato
Deciduous Fruit and Tree Nut	Poultry
Economics	Refrigerated and Frozen Products
Farm Equipment and Structures	Rice
Feed and Forage	Seed
Food and Nutrition	Sheep and Wool
Food Distribution	Soils, Water and Fertilizer
Forestry	Sugar
Grain	Tobacco
Home Economics	Transportation

This progress report was compiled under the leadership of Roy Magruder, Executive Secretary, Vegetable Research and Marketing Advisory Committee, Office of the Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

CODES TO DESIGNATE UNITS CONDUCTING RESEARCH

AGRICULTURAL RESEARCH SERVICE (ARS)

Farm Research Divisions

AE	.....	Agricultural Engineering
ADP	.....	Animal Disease and Parasite
AH	.....	Animal Husbandry
CR	.....	Crops
ENT	.....	Entomology
FE	.....	Farm Economics
SWC	.....	Soil and Water Conservation

Utilization Research and Development Divisions

EU	.....	Eastern
NU	.....	Northern
SU	.....	Southern
WU	.....	Western

Home Economics Research Divisions

CH	.....	Clothing and Housing
HHE	.....	Household Economics
HN	.....	Human Nutrition

AGRICULTURAL MARKETING SERVICE (AMS)

Economics Statistics Divisions

AEC	.....	Agricultural Economics
AES	.....	Agricultural Estimates

Marketing Research Divisions

MD	.....	Market Development
ME	.....	Marketing Economics
MQ	.....	Market Quality
TF	.....	Transportation and Facilities
FCS	.....	FARMER COOPERATIVE SERVICE
FAS	.....	FOREIGN AGRICULTURAL SERVICE

FOREST SERVICE (FS)

Forest Research Divisions

FDR	.....	Forest Diseases
FER	.....	Forest Economics
FFR	.....	Forest Fire
FIR	.....	Forest Insect
FMR	.....	Forest Management
FPR	Forest Products Utilization
RMR	Range Management and Wildlife Habitat
WMR	Watershed Management

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I. FARM RESEARCH

A. Breeding and Genetics

1. PLANT INTRODUCTION AND EVALUATION

CR

Problem: Germ plasm is needed from foreign centers of origin to increase the genetic base for vegetable variety improvement. Introduced germ plasm must be evaluated before it can be used effectively in vegetable improvement.

Program: Emphasis has been placed on the introduction and screening of vegetables for genetic characters needed in the improvement of existing commercial varieties and on the introduction of improved varieties not yet tested in the United States. This long-term program involves locating sources of common disease and insect resistance, color, firmness, good quality of flesh and other characters needed by breeders to improve and tailor our present day vegetable varieties to changing consumer demands. The equivalent of four to five professional Federal man-years are required for the vegetable aspects of introduction and development. The work is conducted at Beltsville, Maryland, and at four Regional Introduction Stations operated in cooperation with the State Experiment Stations of the respective regions.

Progress: During the past year 1119 introductions of vegetables have been received from foreign sources and distributed either to the four Regional Plant Introduction Stations or directly to research workers in State or Federal programs. All major vegetable crops and many minor crops are represented in this program. Usually the items distributed are basic materials for vegetable breeding. A few are commercial varieties from other countries.

The initial evaluation of vegetable introductions is conducted at the four Regional Cooperative Plant Introduction Stations, where seed increase and plant evaluation take place prior to distribution. The screening of these introductions is designed to reveal outstanding plant characters useful to vegetable breeders.

The first major exploration for vegetable material is being carried out in Western Europe this summer and has as its main objective the collection of vegetable lines containing those specific genetic characters most needed by vegetable breeders at this time.

Plans: Exploration and introduction of vegetables will continue. Recommendation from advisory committees, research agencies and related groups will provide the means of efficient planning to meet future research needs.

2. BREEDING AND GENETICS

CR

Problem: With increasing need for higher efficiency, better adaptability to mechanized production and modern processing, higher quality to suit modern tastes and to compete successfully in the market, new varieties of

all kinds of vegetables are needed. These varieties must be high-yielding, resistant to specific diseases, insects, nematodes, or other troubles, and of high nutritional market value.

Program: This is a long-term program involving both basic and applied research. About 21 professional Federal man-years are devoted to the work. Federal men are located at Beltsville, Maryland, and at 12 other locations in 11 States. Cooperative work with State personnel is conducted at about 20 other locations. All the work is cooperative with State experiment stations. Formal cooperation of grower's organizations, food processors, common carriers, seedsmen, and other private agencies also contribute to the program.

Progress: Bean Breeding. Great Northern 1140, the newly developed mosaic- and rust-resistant dry bean, continued to perform in a highly satisfactory manner in 1958. It outyielded the commercial Great Northerns U.I. 31 and 123 in seven out of nine test locations and is about a week earlier than these varieties. Approximately 700,000 pounds of seed was certified in Idaho in 1958. (In cooperation with Montana and Idaho Agricultural Experiment Stations.)

In ten trials in Michigan, Sanilac and a closely related type resistant to two strains of common mosaic (No. 3593) produced 19 percent and 9 percent more marketable beans than Michelite. (Cooperative with Michigan Agricultural Experiment Station.)

Over 100,000 pounds of Tendercrop, which was released early in 1958, was in the seed trade in 1959. Much of this seed was planted for seed increase in 1959 although a substantial amount was grown and processed by freezers. Sufficient seed should be available for all processors desiring it by 1960. A manuscript on the variety has been published by two trade papers.

Thaxter, a new downy mildew-resistant lima bean of Thorogreen type, which was released to seedsmen in 1958, performed well under a wide range of conditions. Approximately 500,000 pounds of seed was produced by seedsmen in 1958 and was available to lima bean growers for planting.

Piloy, a small red-seeded bush lima (P.I. 189403) from Guatemala, was the only lima bean found that resisted a new race (B) of downy mildew that was isolated in 1958 as well as Race A. This variety has been crossed with Thaxter and several promising Fordhook types in order to develop resistance to both races of the downy mildew fungus.

Extender, an all-purpose dark-green variety (B2567-1) was introduced January 1, 1959, when 91,800 pounds of seed were available. It is very early and stores well at room temperature. It produces a U. S. Fancy frozen pack. It is more productive than Wade and is resistant to common bean mosaic, pod mottle virus, New York 15 virus and to many races of rust, and is tolerant to powdery mildew. It performed well in 1959 in many districts.

Cabbage breeding. Large-scale field testing of advanced lines for clubroot, yellows and mosaic resistance, along with maturity, type, size, color, leaf lap, texture, and core length is being continued. Foundation seed of a new cabbage line with triple resistance (clubroot, yellows and mosaic) is now being increased in the greenhouse.

Plant size and abnormalities. Families apparently homozygous for dwarf and for small plant sizes have been obtained through selection. The former is sublethal. Families nearly homozygous for large size have also been obtained by the same means.

The first generation of crosses between abnormal and size types discloses genetic differences among families of the same size group and, to a smaller extent, among families of the same abnormal type. These first generation families tend to be bimodal with respect to plant size.

The abnormal type with anastomosing leaves is now almost homozygous. It appears early in the fall when temperatures are high. Later, with the onset of cool weather, any lateral bud that may develop produces a normal shoot with respect to this character.

Cripple leaf, which greatly deforms a few leaves or may stunt the entire plant, is now appearing in fairly large numbers where selection has been made for this character.

Carrot breeding. In Idaho the main emphasis has been upon inheritance and development of male-sterile inbred lines for production of hybrid carrots and upon inheritance of specific characters. Cooperative with Idaho Agricultural Experiment Station.

In Wisconsin, Michigan, and New York, work is underway on inheritance of male-sterility, carotene content, quality, bitterness and other characters, leading to the improvement of carrots for fresh market as well as for processing. Cooperative with the respective State agricultural experiment stations.

Selections of carrot lines have been made for absence of greening on the shoulders. The character appears to be under genetic control. Selections of roots have been made that are possibly resistant to *Cercospora* and *Alternaria*.

Sweet corn breeding. Inbred lines. Thirteen of the older inbreds are proving useful sources of resistance to the earworm. Five of these have come from M97 and three from M113. There are seven of the newer inbreds that combine earworm resistance with genes for high quality and ten inbreds are primarily sources of high quality, including high sugar content.

Two sweet corn inbreds, 245(9)1 and 166(11)1, developed in cooperation with the Purdue University Experiment Station, were released to breeders and producers in 1959. These inbreds have shown resistance to damage by corn earworms due to a lethal agent in the silks. Both inbreds have been selected primarily for resistance to the earworm but due to the difference in kernel color cannot be used in hybrid combination. Their greatest value lies in their possible use as sources of resistance in future breeding work.

Hybrids. The three most promising combinations involve M97 and LeFever inbreds, and M113 with both LeFever and Huron inbreds. Some 120 nicking combinations are being grown in observational trial this season and seven in replicated trial. Twenty-five hybrid combinations were considerably more resistant than the check varieties in 1957 or 1958, and surpassed them in eating quality.

Diploid parthenogenesis. All tests of materials thought to have had a parthenogenetic origin support this hypothesis. These tests include data on plant height as a measure of vigor and on plant color. A good deal of additional material that may have had a parthenogenetic origin has been and will be grown in 1959.

Lettuce breeding. In breeding for new lettuces suited to Texas conditions, downy mildew-resistant line 174-15 was released under the name Valverde. (In cooperation with the Texas Agricultural Experiment Station, the Texas Citrus and Vegetable Growers and Shippers, and the American Refrigerator Transit Company.)

In the Central-Coastal district of California, three new varieties were released to seedsmen for increase and for general sale after July 1, 1959. They are: Golden State C (6068) and Golden State D (6067), sister lines of Golden States A and B, released a year ago, and Vanguard (6701). The Golden States are Great Lakes types -- large, slow-bolting, tipburn tolerant, crisphead varieties. Vanguard is a new type derived from a cross with the wild species, *Lactuca virosa*. It is a large, dull green, crisphead type with a creamy-colored interior, a very high eating quality, and a softer textured leaf than the Great Lakes types. The strain was released with fairly high residual variability which will enable seedsmen to select further for horticultural type. The variety Climax (5550) was also released to seedsmen for increase and for general sale after July 1, 1959. It is primarily suited for the Imperial Valley of California. It is a large, dark green, crisphead type of high eating quality. (In cooperation with the California Agricultural Experiment Station.)

Several new breeding projects were initiated. The most important involves a search for genetic resistance to common lettuce mosaic, the major economic disease in California. This problem is being attacked in two ways: screening of domestic and foreign varieties of *L. sativa* and wild *Lactuca* species for resistance; and X-radiation of commercial varieties in an attempt to induce mutations giving genetic resistance. Other new programs involve breeding for resistance to big vein, root aphid, and downy mildew. Crosses of commercial varieties with resistant strains have been made.

Genetics research is developing in two phases. Qualitative studies include the identification of an inquiry into mode of inheritance of major genes controlling morphological characters, male sterility, and disease resistance, and the development of a lettuce linkage map. Quantitative studies have been started on mature plant height and core diameter. The objectives in these latter studies are twofold: to discover the mode of inheritance of the traits and to contribute to the development of more efficient methods of analysis.

Muskmelon breeding. Breeding for resistance to two races of powdery mildew was continued in all areas, and special attention given to downy mildew in Texas and the Southeast. In the West, special attention was given to: breeding for resistance to crown blight. One hundred seven F_5 and F_6 progenies, derived from two crown blight resistant F_3 sibs from the cross PMR inbred 36486 x $\frac{1}{4}$ 45 x $\frac{1}{4}$ 450, were planted in replicated 50-plant plots in an isolated 4-1/2-acre field at the U. S. Southwestern Irrigation Field Station at Brawley, California. The field was located in a district where crown blight has been very severe in preceding seasons. In contrast with the poor performance of commercial varieties and susceptible breeding lines in earlier years, all of the progenies grew very vigorously, completely covered the beds, and remained green until harvest was nearly completed. Many plants in several progenies produced excellent fruits. Special attention in selection was devoted to good net development, freedom from stem-end cracking, high quality, and firm flesh.

Fruit setting was late and erratic in the isolated planting. That habit was less apparent in mixed plantings. Erratic fruit setting behavior appeared to be related to dry nectaries and failure of the flowers to attract bees. Dry nectary, a new defect in the muskmelon, was first observed in 1957 in the F_4 parents of these progenies. Subsequent studies have demonstrated that it does not occur in the parent lines and varieties, and it has not been observed in other muskmelons. Genetic work is in progress to control it.

Breeding for resistance to powdery mildew. About 100 breeders' lines were rated for vigor, disease resistance, earliness, prolificacy, and quality in cooperative plantings at five locations in the Rio Grande Valley. Selections from La Jolla retained their foliage longer than most lines, but they were erratic in fruit setting behavior and subject to stem-end cracking. Two lines from Charleston and two lines from Weslaco were judged to be suitable for trial in one-half-acre blocks.

Breeding for quality. It appears that poor quality in the Southeast is not primarily a result of low resistance to disease, but is due to an unfavorable response to high temperature and soil moisture characteristic of the southeastern region. Suitable new genetic stocks are required to solve this problem through breeding. Stocks that flower early and are slow to ripen may be found to have better quality.

Onion breeding. The hybrid Empire, pedigree B2276 x B2215, was named and released in cooperation with Idaho and New York Agricultural Experiment Stations in early 1959. The seed trade has been furnished the inbred parents earlier.

The inbred B5546 White Perianth was released to the seed trade in November 1958. It is the first of many marker genes which will be released to facilitate roguing and help the seedsmen maintain purer and better foundation seed. The white perianth selection of B5546 differs from the original release only in the color of the flower. Any outcrossing to green perianth in the recessive white perianth line can be detected before full bloom of the flower.

The onion inbreds U16-3-11 and U16-3-10-2 were released in cooperation with Utah Agricultural Experiment Station to the seed trade in January 1959. The inbreds originated from the variety Cochise Brown and both combine well with B2215 C, B12115 C, and B12132 B. U16-3-11 is a good seed producer.

The onion inbreds P1015 C and P74-9C were released to the seed trade in early 1959 in cooperation with Idaho Agricultural Experiment Station. Both inbreds are out of Yellow Sweet Spanish. P1015 C is resistant to the Texas strain of pink root.

The inbred B2264prrr was released in cooperation with the Texas Agricultural Experiment Station to the seedsmen in November 1958 as an A and B line to be used as a pink-root resistant seed parent. The inbred B2264 B prrr is a pink-root-resistant derivative of B2264 B, the seed parent of the onion hybrid Epoch. The pink-root resistant selection will perform the same as the original release where pink root is not a problem. It has been tested for resistance only under field conditions in Texas.

Spinach breeding. Spinach breeding line 5 x 1 was released to seedsmen and other breeders by the Department and the Texas Agricultural Experiment Station. 5 x 1 is a smooth-leaved, upright, fast-growing spinach of Viroflay type that is immune from Race 1 of the fungus causing blue mold. It is not resistant to mosaic.

Breeding Line 5 x 1 has proven to be outstanding experimentally as a parent in hybrid combination with other spinach lines and varieties for producing disease-resistant, high yielding, high quality hybrids adapted to the fall and winter spinach-growing areas. Limited trials indicate that Breeding Line 5 x 1 is an excellent parent for use with long-day types to produce disease-resistant, fast-growing, slow-bolting hybrids adapted to the Northern and Western spinach-producing areas.

Approximately 150 plant introductions from 12 foreign countries (Afghanistan, Belgium, China, Ethiopia, India, Iran, Italy, Japan, Korea, Syria, Turkey, Yugoslavia) have been screened for resistance to white rust under controlled greenhouse conditions. All became infected; however, 19 showed a low to a medium level of resistance to infection and 11 of these showed

moderate to high resistance to lesion development. Approximately 50 plant introductions and F_2 progenies from crosses between resistant selections and commercial spinach lines were screened for resistance in the field. Four selections and about 20 percent of one F_2 progeny showed a high level of resistance to infection under a severe epidemic of white rust. The search for immunity to the disease will continue and the present level of resistance will be incorporated into commercial spinach types.

Sweetpotato breeding. APACHE, (Beltsville selection B-5941, included in earlier Regional Tests) has been released primarily for culture under Western irrigated conditions. (cooperative with California and New Mexico)

Roots of this variety have an attractive orange-colored skin with good "finish," and bright orange flesh with a carotene content about one-third higher than in good Porto Rico stocks. Roots are of medium size, smooth, tapered-spindle to short-cylindrical in shape. Root set is moderate to heavy. Baking quality of the "moist" or soft-fleshed roots is very good; color uniform golden orange; flavor and sweetness very good; texture smooth. Apache roots store and handle well and produce an abundance of early moderate-size sprouts in the plant bed.

Apache has produced moderate to high total and marketable yields at numerous locations throughout the United States where it has been tested and where the fusarium wilt or stem rot disease has not been severe. This variety is very susceptible to the stem rot disease but shows some resistance to black rot, to root knot, and to cracking.

Tomato breeding. Extensive breeding, selecting, testing, and evaluating work continued at all locations.

Male sterility. Male sterility has been added to several breeding stocks. Unfortunately, male sterility is closely linked genetically with poor fruit quality. This linkage will have to be broken before the character will be useful commercially.

Breeding technique. Phenotypic balance is emphasized and a system of adaptive indices to measure this is being developed. It is believed that the avoidance of the extreme expression of any character is desirable in breeding because extremes of any kind tend to reduce the range of general adaptation.

Brittle stem. This sublethal character behaves as a simple recessive. It expresses itself only under conditions of high temperature such as obtain under summer field conditions in the Charleston area and near Pretoria, Union of South Africa, where a cooperative test was undertaken.

Breeding for resistance to tobacco mosaic virus. Breeding for mosaic resistance has continued. The most resistant lines were intercrossed to maintain, and possibly improve,

resistance and horticultural quality in the progenies and to avoid introducing more genes for mosaic susceptibility through further backcrossing to commercial varieties which are all susceptible. Populations of 86 lines from these crosses were tested for resistance to mosaic. Plants selected for resistance from each of the lines were fruited in the field. Single plant selections were made from 85 of the 2000 plants in the trial. During the winter of 1958-59, 8500 seedlings grown from the field selections were inoculated and evaluated for mosaic resistance. Some lines showed practically no mosaic symptoms and symptoms were very mild in nearly all the lines.

Seed irradiated at the Brookhaven National Laboratories in 1955 has as yet yielded no progeny showing resistance to curly top.

New varieties released. Two verticillium- and fusarium-resistant varieties, Pearson VF-6 and Pearson VF-11, were released to seedsmen in cooperation with the California Agricultural Experiment Station. Pearson VF-6 has slightly larger fruit and is earlier than Pearson. It is best adapted to the California coastal areas. Pearson VF-11 is similar to Pearson in maturity and has larger fruit. It seems better adapted to the central valleys of California.

Watermelon breeding. Varieties released in recent years account for 95 percent or more of the commercial watermelons produced in the Southeastern United States. Attention is now devoted mainly to basic genetic studies and search for further resistance to anthracnose and to other diseases.

Plans: It is planned to continue work on the several indicated objectives with the several crops listed above on essentially the present scale, assuming no change in available resources.

Arrangements have been made for initiation of modest USDA participation in pea breeding investigations for resistance to pea enation and other viruses in cooperation with the Oregon, Washington, and Idaho Experiment Stations. Continuation and future plans will be contingent upon the availability of resources.

Publications: Nemagreen -- A New Lima Bean Variety Recommended for Nematode Infested Areas. R. E. Wester, H. B. Cordner, and P. H. Massey, Jr. Amer. Veg. Grower. May 1958.

Penetrance and Expressivity of Six Characters of Cabbage. S. H. Yarnell. (ABS.) X Intern. Cong. Genetics 2: 326-327. 1958.

Is Parthenogenesis Possible in Sweet Corn? S. H. Yarnell and Walter A. Hills. Proc. Amer. Soc. Hort. Sci. 73: 407-414. 1959.

Natural Cross-pollination in Lettuce. R. C. Thompson, Thomas W. Whitaker, G. W. Bohn, and C. E. Van Horn. Proc. Amer. Soc. Hort. Sci. 72: 403-409. 1958.

History and Development of Downy Mildew-Resistant Head Lettuce. Thomas W. Whitaker, G. W. Bohn, J. W. Welch, and R. G. Grogan, Proc. Amer. Soc. Hort. Sci. 72: 410-416. 1958.

USDA Active in Lettuce, Melon Breeding Program. Thomas W. Whitaker and G. W. Bohn. Western Grower and Shipper 29(12) 2 p. 1958.

Plant Breeding and Cytogenetics. A Review. Thomas W. Whitaker. Jour. Hered. 49:237 and 242. 1958.

Delta Giant, a New Long Season Shallot. D. Y. Perkins, A. E. Kehr, R. T. Grown, E. C. Tims, and J. C. Miller. Louisiana Agricultural Experiment Station Circular No. 52. March 1958.

The Cytology and Plant Characteristics of an Amphidiploid Derived from *Allium ascalonicum* x *A. fistulosum*. S. T. Jones and A. E. Kehr. Amer. Jour. of Botany 44: 523-529. 1957.

Male Sterility in Onion Plants from Turkey. Elmo W. Davis. Jour. Hered. 49: 31-32. 1958.

An Interspecific Cross in *Cucurbita* (*C. lundelliana* Bailey x *C. moschata* Duch.). Thomas W. Whitaker. Madrono 14: 4-13. 1959.

A Temperature Sensitive Sublethal Mutant in Tomato. J. R. Wall and C. F. Andrus. Tomato Genetics Cooperative Report No. 9, 1959. Univ. of Calif., Davis, California.

Progress Report of National Screening Committee for Disease Resistance in the Tomato for 1954-57. Summary of tests by various workers including S. P. Doolittle. Pl. Dis. Reprtr. 43(1): 55-56. 1959.

The Tomato Breeding Program of the U. S. Department of Agriculture. S. P. Doolittle. Proc. of Natl. Canners Assoc., 1959. (Compiled from reports of workers mentioned in the text at the request of the National Canners Association.)

B. Physiology and Nutrition

3. TOXIC EFFECTS OF PESTICIDES ON PLANTS

CR

Problem: Under certain conditions some pesticides tend to accumulate in some soils to the extent that they impair growth of some plants, or impair food or feed quality of the plant product. It is important to know the persistence of different toxic chemicals in soils, whether they enter plants, and what happens to them and the plant's processes if they enter.

Program: This long-time basic study is being conducted at Beltsville, Maryland and (exclusive of soil analyses by ENT) involves one professional man-year per year. It is integrated with related research conducted by the Entomology Research Division.

Progress: Metabolism of lindane. A chlorine-containing substance (a product of metabolism) was found in lindane-treated carrot plants. Although not positively identified, this metabolic-breakdown product of lindane is probably pentachlorocyclohexene or a closely related compound. The substance has not been found as yet in lindane-treated potatoes, tomatoes, beans, and corn. A modified method of paper chromatography was developed and used to demonstrate the presence of this metabolic breakdown product of lindane within the carrot plant.

Experiments are in progress to identify and quantitatively measure this substance in plants. Insecticide uptake by plants and micro-organism metabolism of lindane are associated main areas of investigation.

Persistence of pesticides in soil. Soil samples were taken in 1958 after an interval of three years from experimental plots at Beltsville in a long-time study of the rate of disappearance of residues of several insecticides. These samples are analyzed for specific chlorinated hydrocarbons or for organic chlorine by the Pesticide Research Laboratories of Entomology Research Division at Moorestown, New Jersey. The analyses made last year marked the twelfth year of the tests. They are being coordinated with data from previous years.

Plans: Work will continue on essentially the same basis as at present for the near future. Attention will be given to the identity and nature of the metabolic products of chlorinated hydrocarbons.

Publications: Demonstration of Lindane and a Lindane Metabolite in Plants. by Paper Chromatography. J. P. San Antonio. Jour. of Agric. and Food Chem. 7(5): 322-325. 1959.

Effects of Some Environmental Factors on Respiration, Gas Content, and Keeping Qualities of Porto Rico Sweetpotatoes. L. J. Kushman and M. T. Deonier. Assoc. Sou. Agr. Workers, Proc. 55th An. Conv.:155-156. 1958.

Effects of Weather, Date of Harvest, and Curing Treatments on Keeping Qualities of Porto Rico Sweetpotatoes. L. J. Kushman and M. T. Deonier. Proc. Amer. Soc. Hort. Sci. 71: 369-375. 1958.

What Makes Fruits and Vegetables Good? Victor R. Boswell. In Food Yearbook of Agriculture, pp. 371-377. 1959.

Farm Practices, Quality and Cost. Victor R. Boswell. In Food, Yearbook of Agriculture, pp. 396-407. 1959.

4. SEED INVESTIGATIONS

CR

Problem: Fundamental information on seed physiology is essential to the development of new and improved methods of vegetable seed production, as well as to all agricultural practices involving the growing and harvesting of seeds and the utilization of seed in crop production or seed storage. Since seeds from different kinds of plants germinate by essentially similar physiological processes, and since these processes are very poorly understood, this research utilizes those seed types that best illustrate fundamental principles.

Program: A long-range continuing investigation involving basic physiological studies at Beltsville. Certain phases of the work are in cooperation with the Mineral Nutrition Pioneering Research Laboratory of the Soil and Water Conservation Research Division; the Plant Physiology Pioneering Research Laboratory, the Peanut Section of the Oilseed and Industrial Crops Research Branch; and the Ornamentals Section of the Vegetables and Ornamentals Research Branch, all of the Crops Research Division. The work in this laboratory involves about two professional Federal man-years annually.

Progress: Seed dormancy and germination. It has been known for a century that light is an important factor in the germination of the seeds of many species of plants. These seeds possess a block to the germination process; light can remove this block. We reported in recent years that germination is reversibly controlled by low energies of light (red light causing the seeds to germinate and far-red light preventing germination). The controlling mechanism is a single, repeatedly photoreversible reaction, the so-called photomorphogenic reaction, which also controls stem elongation, flower formation and production of some plant pigments.

The general occurrence of this effect of low energies of light is shown by the discovery that the germination of some tree seeds (Princess tree and loblolly pine) is controlled by the same light mechanism as some vegetable (Grand Rapids lettuce) and weed (peppergrass) seeds. However, the sensitivity to red and far-red light can be shown. Loblolly pine seeds require a period of exposure to low temperature before a uniform and sensitive light response develops. Thus, although it may be modified by other factors, single light-controlled physiological mechanism may be shown to control the germination of many seeds.

As indicated above, previous work has shown that germination blocks may be removed or imposed by different treatments such as light and temperature. Recently we have shown that blocks can also be removed by chemical treatments with gibberellic acid in the case of light-requiring seeds such as Grand Rapids lettuce and peppergrass; such treatment also modified the temperature sensitivity of the seeds.

Storage of beans, kenaf, and hemp seed. A study was undertaken to follow the effects of mechanical injuries to snap bean seeds during harvesting and processing on the storage properties of the seed. Commercially processed snap bean seeds from 13 bulk lots of five varieties were stored for 45 months in open warehouses in the localities of California, Idaho, and Wyoming where the seed had originated, and also in the open warehouses and controlled storages at one or more of three other locations: Mercedes and San Antonio, Texas, and Milford, Connecticut. No seed lot showed a significant change of germination percentage during the entire period of storage at the places of origin or in the controlled storage at Milford or that at San Antonio. All lots deteriorated rapidly where temperature and humidity were high. Where germination decreased, in general it decreased more rapidly in lots with much mechanical damage than in less damaged lots.

In an emergency, seed of kenaf and hemp may be needed for the production of these crops in the United States, although at the present time they are not produced in this country. Therefore, in 1948-50, a study of conditions for long-time preservation of kenaf and hemp seed was initiated. Seeds were stored under various controlled temperature and humidity conditions at Beltsville, and under uncontrolled conditions at localities with various climates. Kenaf and hemp seed conditioned to 8 percent moisture retain full viability when stored at 10° C. or lower temperature for 5½ and 8¼ years, respectively. Viability decreases rapidly under natural conditions in some areas where the crops are grown.

Since the seeds reach equilibrium with the relative humidity of the air and since the moisture content is the factor governing the length of seed viability at a given temperature, there is much interest in moisture-proof containers for the holding and shipment of seed. Kenaf seed placed in several bags of each of several materials (5 and 10 mil polyethylene, laminated cellophane, and cloth) were shipped to and stored in Havana, Cuba, for 3, 15, and 27 months. Other bags containing seeds were retained in the laboratory at Beltsville. Viability of the seed thus stored indicates 10 mil polyethylene would be useful for shipment and for short-time storage of seeds such as kenaf in the Tropics. These materials are not sufficiently moisture resistant to protect seeds for more than a few months in a humid climate.

Plans: Since it can be shown that a number of factors can modify germination, the problem now is to explain the physiological and biochemical action of such factors and to relate this information to cultural practices and production problems. The direction of the work in CR, ARS, is therefore being modified to provide parallel physiological and biochemical observations in the hope of obtaining a much more basic picture of seed development, dormancy, and germination than is now available.

Storage studies begun by CR in ARS many years ago are now completed. Further work in storage will be continued by AMS.

Publications: Action of Light on Germination of Seeds of Paulownia tomentosa. E. H. Toole, Vivian K. Toole, H. A. Borthwick, S. B. Hendricks, and R. J. Downs. (Abs.) Pl. Physiol. 33 (Sup.):xxiii. 1958.

The Germination Response of Seeds of Pinus taeda to Light. Vivian K. Toole, H. A. Borthwick, E. H. Toole, and A. G. Snow, Jr., (Abs.) Pl. Physiol. 33 (Sup.): xxiii. 1958.

Germination of Grand Rapids Lettuce and Lepidium virginicum Seeds as Affected by Gibberellin. Vivian K. Toole and H.M. Cathey. (Abs.) Pl. Physiol. 34 (Sup.): xvi. 1959.

C. Cultural Practices

5. VEGETABLE SEED PRODUCTION

CR

Problem: Relatively little research has been conducted on vegetable crops with special reference to cultural and management practices and their effects on yield and quality of seeds for planting. Optimum practices for producing vegetables for food may not be, and often are not, optimum for most economic production of seed of the desired high quality for planting. Knowledge of effects of time and rate of planting, fertilizer practice, water supply, pollinating insects, time and manner of harvest, and handling the seed on the farm is meagre. Studies of modest scope in the past dozen years indicate that highly significant and profitable improvements can be developed.

Program: This is a small long-time project involving one professional man headquartered at Logan, Utah, and in cooperation with the Utah and Idaho Agricultural Experiment Stations. Field work is all done in the West, laboratory evaluations are done at Beltsville. One to two professional Federal man-years per year are devoted to these studies.

Progress: Special attention is now being given to the effects of timing and amounts of water supplied and to fertilizer applications on the yields and seed quality of beans and peas. The work has not proceeded far enough to permit conclusions. It appears, however, that some significant responses of economic value are developing.

Seed carrots. An irrigation-spacing-nitrogen study on seed-to-seed carrot was continued at Logan, Utah, in an effort to fill a gap in information from earlier studies. Plots were irrigated when resistance at the 24-inch depth reached 5,000 ohms (High-Low moisture) or 75,000 ohms (Low moisture), up to June 24 after which all plots were irrigated at 75,000 ohms until

near harvesttime when no more water was applied. Rows were spaced 24, 30, and 36 inches; and 0 or 80 pounds per acre were applied. Seed yield ranged from 719 to 1,021 pounds per acre. On the average the High-Low moisture outyielded Low by 17 percent; 24-inch spacing outyielded 30 and 36 inches by 10 percent; and 80 pounds of N as contrasted with no N increased yield 12 percent. However, the best yield was from High-Low irrigation in 36-inch rows treated with 80 pounds N per acre where the plants had sufficient N and moisture to utilize the extra space.

Seed onions. Cooperative studies with Entomology Research Division at Logan, Utah, were continued to determine the effects of different kinds and numbers of insects for the production of open-pollinated and of F_1 hybrid onion seed. Consideration is given to both yield and quality of seed produced.

In cooperation with Crops Protection Branch studies of weed control in seed onions are conducted at Logan.

Plans: Work will be continued for the present year at essentially the same scale of operations as last year. The carrot study is being terminated and relatively more attention will be given to the bean, pea, and onion seed studies.

6. CULTURAL PRACTICES AND PROPAGATION OF MUSHROOMS

CR

Problem: There is a continuing need by growers for new information on the suitability and management of different kinds of soil for the casing layer in the mushroom beds, for information on composts and on how to grow certain kinds of mushrooms of high quality that cannot now be cultivated profitably.

Program: This is a small long-time project at Beltsville, Maryland, involving two professional Federal man-years per year. Leads developed in the laboratory and experimental houses are tested on a commercial scale through cooperation of growers in the Kennett Square, Pennsylvania, area. The work is integrated with that of the Pennsylvania Agricultural Experiment Station.

Progress: Casing material. Water must be applied with extreme care to most mushroom casing soils to prevent reduced yields from puddling. This is a distinct disadvantage and means are being sought to overcome it. Principally to avoid this difficulty, peat is used for casing by a majority of the growers in England and Germany, but American growers have been slow to adopt peat moss because of its high cost in this country. Our experiments indicate most of the advantages of casing with peat can be retained at a low cost by top dressing the casing soil with a $\frac{1}{4}$ -inch layer of sphagnum peat moss mixed with limestone.

Culture of new types. A search is continuously being made for new mushroom varieties with superior flavor or growth characteristics. During the past season, two wild species were tested, *Coprinus comatus* and

Agaricus subrufescens. The former yields well but has poor keeping quality and flavor. Work on this species is being discontinued. On the other hand, *Agaricus subrufescens* has an excellent and distinctive flavor and, in addition, grows and fruits at temperatures 15° F. higher than the common cultivated mushroom. This would permit growing it in most localities in the summer months without refrigeration.

Plans: Cultural studies of new types and of casing materials will be continued at about the present level. Studies of artificial composts, their preparation, and microbiology will be expanded.

Publications: Growing Lettuce in Greenhouses. Ross C. Thompson, S. P. Doolittle, and T. J. Henneberry. U. S. Dept. of Agric. Handbook, No. 149. 22 p. 1958.

Asparagus Culture. Ross C. Thompson, S. P. Doolittle, L. L. Danielson, and Horatio C. Mason. U. S. Dept. of Agric. Farmers Bul. 1646. July 1958.

7. SOIL AND WATER MANAGEMENT AND CONSERVATION

SWC

Problem: Moisture conservation is a highly important problem in all vegetable growing areas and farmers are concerned with devising methods of irrigation, prevention of soil and water losses through erosion, and developing soil management and crop rotation systems under which vegetables can be grown economically.

Program: A continuing program to study soil and water management practices which make for more efficient use of water supplies and to increase basic and applied knowledge relating to the soil-water-plant system, including fertility needs. In studies where vegetables are used as tools to gain these objectives about eight professional Federal man-years annually are involved.

Progress: Minimum tillage for tomatoes at Marlboro, New Jersey, not only reduced production costs but increased yields of tomatoes. Mulch tillage, on the other hand, increased the problem of weed control and decreased tomato production.

During 1958, when rainfall was adequately distributed in New Jersey, there was an increase in cabbage yield of 1.9 tons, or 11 percent, by irrigation, but snap beans, sweet corn, and cantaloupes failed to respond to extra water.

Results of a sweet corn moisture fertility study at Yuma, Arizona, indicate that high moisture levels stimulate plant growth. More corn is produced with abundant water during the two-week pollination stage and other periods are less important. By regulating the moisture content of the soil, it is possible to produce good yields of sweet corn on smaller plants.

The consequences of using brackish irrigation water on both crops and soils are being investigated in Virginia. Beans that were irrigated with brackish water with conductivity of less than 6 millimhos/cm yielded better than unirrigated beans, but in every case irrigation with fresh water gave most desirable results. There was apparently an accumulation of salts at the 6 - 12 inch depth of soil where brackish irrigation water was used. It is anticipated that winter rains will leach these salts out of the profile.

A study has been made of the interactive effects of salinity and gibberellic acid (GA) on the dwarf red kidney bean. This study was suggested by recent reports in the literature that GA was able to overcome growth suppression in plants resulting from a number of diverse factors. A large stimulation of growth was obtained with GA under nonsaline conditions. In the presence of high levels of salinity, however, the GA effect was virtually abolished. GA was, therefore, unable to overcome the growth suppression imposed by salinity.

An experiment was designed to study the effect of initial sodium content on the subsequent accumulation and distribution of sodium in plants. Beans, which tend to restrict the movement of sodium from the roots to the tops, were used as the test plant. The initial sodium content of the plants was varied by growing them for two weeks in culture solutions of varying sodium-potassium ratios. In order to study the subsequent accumulation of sodium in these plants, they were transferred, for a 24-hour period,

to culture solutions containing nonradioactive sodium. The effect of time on the distribution of radioactive sodium was determined by harvesting plants at 0-, 1-, and two-week intervals following the 24-hour absorption period. The results indicate that there is an inverse relationship between the initial sodium content and the relative amount of radioactive sodium retained in the roots, and a direct relationship between the initial sodium content and the relative amount of radioactive sodium found in the upper portions of the stem. With time, there was an increase in both the relative amount and concentration of radioactive sodium found in the upper portions of the stem, the greatest increase occurring during the first week.

Sand-culture studies were carried out in the greenhouse in order to investigate whether adsorbed sodium per se affects the growth of and the amounts of various cations taken up by plants. At the same time, the experimental design was aimed at segregating the effects due to total salt levels and to specific cations on plant growth. Using two varieties of carrots and green beans as test crops, the conclusion from previous work could be confirmed regarding the fact that sodium and other cations in the free and adsorbed forms, under conditions of chemical equilibrium between the solution and adsorbed phases, are taken up at the same rate. Under nonequilibrium conditions favoring the adsorbed ions, these were taken up faster than the ions in solution. As to the interaction on plant growth of the total salt level and specific cations (Na and Ca), it appeared that the decrease in yield with increasing value of the concentration ratio between these ions in the nutrient solutions used was distinctly greater at the lower than at

the higher total salt concentrations. With increasing magnitude of the total salt concentration of the solutions, the ratio was distinctly greater at the lower than at the higher values of the ratio mentioned. This indicates that saline and sodic effects upon plant growth are interacting. This interaction is statistically significant. The experimental data indicated that there was a significant interaction between the first, or passive, and the second, or active, phase of ion uptake. As to the ultimate chemical composition of the plant tissue, it appeared that the selective abilities of the plant with respect to ions to be taken up dominated over the ionic composition of the exchange sites that are provided by constituents of the cytoplasm and cell wall of root tissue.

Boron is essential for plant growth but concentrations not greatly in excess of that required for optimum growth are toxic to many plants. Because boron occurs in soils in adsorbed as well as in dissolved forms, and soils vary in their boron-adsorptive capacities, the question arises as to whether plants respond to adsorbed boron as such. This question has been studied by comparing the response of beans to excess boron in soils having uniform concentrations of boron in the soil solution but different amounts of adsorbed boron. The results definitely show that plants do not respond to adsorbed boron directly and that response to dissolved boron is influenced by factors in addition to the boron concentrations of the soil solution.

Plans: Most of the work will continue at about the same level. A program is underway to intensify studies on irrigation water management, and to learn the water requirements of irrigated crop interrelationships.

Publications: Salt Tolerance of Vegetable Crops in the West. Leon Bernstein. Agr. Inf. Bul. No. 205. Sept. 1959.

D. Weed Control

8. WEED CONTROL INVESTIGATIONS

CR

Problem: Basic and applied research is needed on the development of new and more efficient chemical, biological, cultural, and mechanical methods of weed control for vegetable crops as a means of facilitating the mechanization of this industry, increasing crop quality and reducing production costs.

Program: This is a continuing long-term program of basic and applied research on the ecological, physiological, and chemical problems associated with the development of practical methods of weed control, including the study of the interactions of soil, climate, and varieties, conducted at Beltsville, Maryland; New Brunswick, New Jersey; Weslaco, Texas; Tempe, Arizona; Laramie, Wyoming; Stoneville, Mississippi; and Prosser, Washington, involving approximately three professional Federal man-years annually.

Progress: Basic and applied research on the control of weeds in vegetable crops has been expanded at Beltsville, Maryland; New Brunswick, New Jersey; and Weslaco, Texas. A weed control research specialist has been placed at

the New Jersey Agricultural Experiment Station to conduct research on vegetables and other horticultural crops with greatest emphasis on vegetable crops.

Fundamental investigations. Studies on the mechanisms of action of herbicides at Beltsville, Maryland, and in North Carolina showed that the triazine and phenylurea herbicides kill plants by reducing the efficiency of photosynthesis. Dalapon kills weeds by inhibiting the synthesis of pantothenic acid, a B vitamin, essential to plant growth. The results of these investigations aid in the systematic synthesis of new herbicides and the more efficient use of those currently available.

Laboratory studies on the herbicidal activity of CIPC impregnated on attapulgit, vermiculite, pyrophyllite, perlite, and charcoal granules showed that this herbicide was contact and vapor-active and that its herbicidal activity was lowest on granular carriers of high adsorptive capacity. Treated granules that disintegrated on contact with water showed an increase in activity under moist conditions. Field studies in New Jersey and Texas and at Beltsville, Maryland, showed that granular herbicides were effective and that crop selectivity was enhanced compared to sprays.

Laboratory and field investigations on the control of nutgrass in Georgia showed that the herbicidal activity of dalapon on this weed was greatly increased when it was used in combination with gibberellin treatments.

Additional studies in Georgia, Texas, California, and Oregon have contributed basic information on the effect of climate, soil, form of application, soil placement, and method of irrigation on herbicidal effectiveness and crop response of a number of chemicals.

Development of chemical and cultural weed control practices in crops. Progress in these studies on weed control in vegetable crops is described under the following crop headings.

Beans. Preplanting soil incorporation on EPTC showed promise for the control of weeds in beans in studies conducted in Washington, Wyoming, and at Beltsville, Maryland.

Bulb crops. A number of herbicides in spray and granular form were evaluated for control of weeds in onions in Texas. CDEC at 6 lb/A in spray and granular form and diuron at 0.66 lb/A in granular form were effective as post-emergence applications.

Cole crops, greens, and salad crops. Winter weeds such as chickweed and henbit, and annual grasses are serious problems in these cool weather crops. In experiments at Beltsville, Maryland, pre-emergence applications of CDEC at 2 lb/A in combination with CIPC at 0.5 lb/A effectively controlled these weeds in cabbage, spinach, mustard, turnip greens, and lettuce.

Peas. Evaluation of several herbicides for control of weeds in canning peas in Montana indicated that early post-emergence applications of CDAA will effectively control annual weeds in this crop. Pre-seeding, soil-incorporated applications of EPTC reduced pea yields and reduced germination of seed produced by the surviving crop plants.

Sweet corn. Annual grasses and broadleaved weeds in eight varieties of sweet corn were effectively controlled using simazin at 4 lb/A in experiments at Beltsville, Maryland, without reducing yield or quality of the crop.

Pre-emergence applications of dinoben effectively controlled annual grasses and broadleaved weeds in sweet corn without injuring the crop in preliminary studies at Beltsville, Maryland.

Sweetpotatoes. Spray and granular forms of CIPC at 3 lb/A applied immediately after planting and again at lay-by controlled annual grasses and broadleaved weeds in sweetpotatoes without reducing yield or quality of the crop in experiments conducted at Beltsville, Maryland. In associated preliminary studies, EPTC applied at 5 and 10 lb/A immediately after planting, without soil incorporation, effectively controlled weeds without injury to sweetpotatoes.

Tomatoes. The development of methods of direct seeding and mechanical harvesting of tomatoes has been progressing rapidly and effective chemical methods of weed control are needed to facilitate this program of mechanization. Preliminary studies conducted at Beltsville, Maryland, indicate that applications of dinoben immediately after seeding may prove useful in this problem.

The control of weeds after the last cultivation in transplanted tomatoes is a problem of major importance. Spray and granular applications of EPTC at 5 lb/A, not soil incorporated, effectively controlled weeds without reducing yield or quality of the crop. Similar applications at 10 lb/A reduced the yield of tomatoes.

Plans: New herbicides, combinations of herbicides, methods of application, mechanical methods, cultural practices, and various combinations of these methods, will be studied on a continuing basis to develop more efficient methods of weed control for vegetable crops. Associated basic research will include the study of the physiological response of these crops to herbicides and the effect of climate and soil on herbicidal effectiveness of the chemicals. Studies will be made on the postharvest physiology, quality, and chemical residue content of herbicide-treated vegetable crops wherever possible in this program.

Publications: The Response of Corn and Rutabagas to DCB, Amitrol, and Dalapon in Irrigation Water. V. F. Burns and J. H. Dawson, Weeds. 1958.

Evaluation of Simazin for Control of Weeds in Sweet Corn. L. L. Danielson. Proc. of Southern Weed Conference, p. 88. 1959 (Abstract).

Logarithmic Sprayer Evaluation of Herbicides in Horticultural Crops. L. L. Danielson and Robert E. Wester. Weeds. 7(3):324-332. 1959.

Recent Advances in Weed Control Research in Vegetable Crops. L. L. Danielson. Proc. New Mexico Fruit & Veg. Growers Short Course. 1959.

Pre-emergence Chemical Control of Annual Weeds in Field Beans. J. H. Dawson and V. F. Burns, Western Weed Control Conf. Res. Prog. Rept. p. 39. 1959.

An Evaluation of Several Chemicals for Their Herbicidal Properties - 1958 Field Results. W. A. Gentner and W. C. Shaw. CR-6-59, ARS-USDA.

Some Responses of Nutgrass (*Cyperus rotundus* L.) to the Potassium Salt of Gibberellic Acid. E. W. Hauser, Proc. Southern Weed Conf., p. 193. 1959 (Abstract).

Responses of Transplanted Sweet Potatoes to Several Herbicides. J. T. Thompson, E. W. Hauser, and A. H. Dempsey, Proc. Southern Weed Conference, pp. 89-92. 1959.

A Preliminary Study of the Interaction of Herbicides and Potassium Gibberellin on Nutgrass (*Cyperus rotundus* L.). E. W. Hauser, Proc. Southern Weed Conference. pp 196-197. 1959 (Abstract)

Rate of Infestation of Nutgrass (*Cyperus rotundus* L.) from Space-Planted Tubers. E. W. Hauser and J. T. Thompson. Proc. Southern Weed Conference, pp. 178-179. 1959 (Abstract).

Beta Alanine Protection of Yeast Growth Against the Inhibitory Action of Several Chlorinated Aliphatic Acid Herbicides. J. L. Hilton, L. L. Jansen, and W. A. Gentner, Plant Physiology 33:43-45. 1958.

Inhibition of the Enzymatic Synthesis of Pantothenate by 2,3-Dichloroisobutyrate. J. L. Hilton, Sci. 128:1509-1510. 1958.

The Influence of Irrigation Methods on the Performance of Pre-emergence Herbicide Treatments. R. M. Menges. Proc. Southern Weed Conf. p. 180. 1959 (Abstract).

Weed Control in Peas with Post-emergence Herbicide Treatments. J. M. Hodgson, Western Weed Control Conf. Res. Prog. Rept. pp. 30-31. 1959. (Abstract).

Suggested Guide for Chemical Control of Weeds. D. L. Klingman, W. C. Shaw, F. L. Timmons, R. J. Aldrich, L. L. Danielson, and W. B. Ennis. ARS 22-46, May 1958, Special Report, pp. 1-55).

Weed Control in Onions with Pre-emergency Applications of Herbicides. R. M. Menges, Southern Weed Conf. Proc. pp. 73-80. 1959.

Chemical Weed Control in Established Tomatoes. R. M. Menges, Proc. Southern Weed Conf. pp. 81-87. 1959.

Studies on the mechanism of Herbicidal Action of 2-Chloro-4,6-bis-(ethylamino)-s-triazine. D. E. Moreland, W. A. Gentner, J. L. Hilton, and K. L. Hill, Plant Physiology. 1959.

E. Disease and Nematode Control

9. DISEASE CONTROL

CR

Problem: Hundreds of plant diseases are causing hundreds of millions of dollars worth of damage or loss in yield, quality, and efficiency of production of vegetables annually in this country. They need to be understood and avoided or brought under control.

Program: A continuing long-term program of basic and applied research involving about 12 Federal professional man-years annually at Beltsville, Maryland; Weslaco, Texas; Twin Falls, Idaho; Prosser, Washington; E. Lansing, Michigan; La Jolla, California; Madison, Wisconsin; Tifton, Georgia, in cooperation with the respective States, regional, and private industry groups.

Progress: The microbiology of soil with reference to disease control. Further progress was made in the development and the evaluation of media and antimicrobial agents used for the isolation and enumeration of soil fungi. Two new media developed in the Vegetables and Ornamentals Research Laboratory at Beltsville and four others have been found satisfactory. Bacterial colonies were completely suppressed by 50 p.p.m. each of aureomycin hydrochloride and streptomycin sulfate. Oxgall at 1/4 to 1/2 percent restrained the spread of fungus colonies on the medium without marked reduction of sporulation.

Several diluents, dispersing agents and modes of agitation were studied in developing methods of soil dispersal to give the best possible counts of microbial numbers.

Considerable attention was devoted to devising media that would give more dependable counts and colony development of streptomycetes as distinct from bacteria. Egg albumin agar was found good, and 50 p.p.m. of actidione in the medium restricted growth of fungi.

A rapid method of isolating *Rhizoctonia solani* from soil by use of buckwheat was developed, which provides a reliable estimate of inoculum potential of the fungus in the soil. The method consists of burying mature

buckwheat stem pieces in infested soil and isolating *R. solani* from the colonized pieces on water agar containing aureomycin hydrochloride, neomycin sulfate, and streptomycin sulfate.

A series of experiments is underway to determine the extent and nature of the rhizosphere microflora as well as the quantitative and qualitative aspects of fungal populations in the rhizosphere of healthy and diseased plants.

Because of its highly suitable root habit, blue lupine was used as the test plant. A micro-sampler was built whereby serial soil micro-samples 3 mm in diameter could be obtained simultaneously from the surface of the roots outward to a distance of 21 mm.

Experiments have been conducted to determine the effects of both mature and immature organic soil amendments on the severity of the Rhizoctonia disease of snap beans and on the populations of fungi, streptomycetes, and bacteria in the soil and rhizosphere of this host. Conclusions drawn from these experiments are: (1) Amendments affect both the expression of the disease and the numbers of micro-organisms in the soil and rhizosphere; (2) mature grain straws impart considerable protection to the host soon after incorporation but rapidly decrease in effectiveness; (3) there is a considerable time lag between the incorporation with the soil of mature leguminous crops and the suppression of *R. solani*; (4) of the several immature amendments tested only oats provided consistent protection to the host; (5) the numbers of rhizosphere fungi and the rhizosphere bacteria/streptomycetes ratios are more closely related to the Rhizoctonia disease index of snap beans than are the R/S ratios for the various groups of microflora.

Investigations now are in progress on: (1) disease severity as affected by the time interval between amendment incorporation and planting date; and (2) by the enrichment of mature amendments with water soluble and water insoluble nitrogen sources at time of incorporation.

Root rot of peas incited by *Aphanomyces euteiches* is one of the most destructive diseases of the root system of this plant. No effective fungicide or resistant variety is known. Experiments to control this disease by biological means have been initiated. Unsterilized Elsinboro sandy loam in ground beds and greenhouse loamy sand in benches were inoculated with virulent cultures of *A. euteiches*. Six consecutive crops of peas were raised in the inoculated soil in order to build up the inoculum potential of the pathogen. Dry and green organic residues were added to the infested soil three weeks prior to planting. Nitrogen and sodium salts were added to the soil two days after planting peas. During harvest particular emphasis will be placed on the relation between disease severity and the numbers and kinds of antagonistic micro-organisms associated with the decomposing organic amendments and with the various forms of nitrogen and sodium.

During July and August many cultures were again isolated from roots of herbaceous plants collected near Beltsville, to determine how common the zoospore-producing variant of *Pythium ultimum* may be in this region.

Observations on aging plate cultures of this unusual variant indicate that its oospores undergo after-ripening more slowly than is usual in *P. ultimum*. Several cultures of *Pythium* were obtained which may represent two new species of the genus. Additional trials were made to obtain zoospores of *Pythium spinosum* and *Pythium scleroteichum* by germination of their after-ripened oospores. Further study was made to set forth the occurrence of *Pythium deliense* and *Pythium indicum* in North America.

Midsummer isolation cultures yielded three additional fungi that destroy nematodes after the manner of parasites, and also two related forms similarly destructive to shizopods. Observations have been completed on a new predacious mold that captures eelworms by means of adhesive knobs borne directly on mycelial threads rather than on stalks.

Bean diseases. Downy mildew of lima bean. A new race of downy mildew infectious to all lima beans tested except the variety Pilroy from Guatemala (mentioned under Breeding) was isolated from a previously resistant line of lima beans in New Jersey in 1958. A simple rapid and inexpensive method for testing lima bean seedlings for downy mildew resistance by using polyethylene bags was developed.

Bacterial blight. In Michigan tests, 8 applications at 7-day intervals of 200 p.p.m. of streptomycin sulfate + 500 p.p.m. of 2 pyridinethiol, 1-oxide copper salt gave excellent control of bacterial blight. Streptomycin alone at 400 p.p.m. failed to control the disease.

Virus diseases. The studies on the two new strains of bean yellow mosaic reported in 1958 were completed and the results are now being prepared for publication. The investigations on a new strain of alfalfa mosaic have also been completed and the manuscript is now being prepared. Two additional new viruses isolated from alfalfa from New Jersey and Idaho both infectious to beans are being identified. Several new strains of common bean mosaic and a new strain of bean yellow mosaic seedborne in beans have been identified in Idaho, Michigan, and Washington, respectively.

Studies of microbiological control of bean root rot in Washington were continued with some interesting observations which remain to be confirmed and interpreted in the light of further work.

Cabbage diseases. Intensive greenhouse testing of infested soil from different regions of the United States is being conducted cooperative with Wisconsin in the search for the existence of races of the clubroot organism by the use of selective pure line differential test plants. The possible existence of more than one physiologic race (mixture of races) in a given field soil is now being investigated. In addition to specialization of the pathogen the effects of spore load, soil reaction, moisture and soil temperature are also being studied under controlled conditions.

New work was initiated on cabbage disease problems in the lower Rio Grande Valley.

Carrot diseases. New work was initiated on carrot disease problems in the lower Rio Grande Valley.

Cucumber diseases in the East. A strain of cucumber mosaic virus 1, which infects and rapidly kills a number of varieties resistant to eight other strains tested, has been differentiated from the type strain by its reaction on various hosts. This strain should be valuable in screening for resistance and a description of its characteristics has been prepared for publication.

Relation of virus diseases to crown blight of muskmelons. Many muskmelon plants showing crown blight and "bronze leaf" symptoms were found to be infected with watermelon mosaic virus. Others were infected by strains of cucumber mosaic virus and also a virus possibly related to that of tobacco ring spot. Inoculation of muskmelon plants in the greenhouse indicates that the watermelon and cucumber mosaic viruses, either alone or in combination, can cause symptoms associated with crown blight and bronze leaf. There seems to be a close relationship between virus complexes isolated from *Physalis* sp. (ground-cherry), *Malva* sp. (cheeseweed), and alfalfa. It is suggested that crown blight losses might be reduced by eliminating perennial weeds and avoidance of muskmelon plantings near alfalfa, sugar beets, tomatoes, and squash plantings which are likely to be virus reservoirs and harbor their aphid vectors.

Pea diseases. Of more than 900 commercial varieties and P.I. lines that were tested for resistance to a new pea streak virus reported from Idaho in 1957 none were resistant. The studies on this disease were completed and a manuscript has been prepared.

Spinach diseases. Sharp-freezing (-10° F.) conidia of the white rust and blue mold fungi with subsequent storage at 0° F. has proven feasible for preservation of inoculum for up to six months. Attempts to germinate the white rust oospore in the laboratory have failed. This work will continue.

Sweetpotato diseases. Insect transmission studies of sweetpotato viruses (in cooperation with F. F. Smith of Entomology Research Division) were continued. Internal cork virus was largely transmitted by aphids while yellow dwarf (formerly called feathery mottle) was transmitted by whiteflies. It was impossible to demonstrate any virus transmission by leafhoppers.

The whitefly, *Trialeurodes abutilonea*, was first demonstrated to spread yellow dwarf virus in Maryland in 1958. Previously only a whitefly which lived overwinter in Florida was known to transmit this virus. The discovery of insect vectors capable of spreading yellow dwarf disease in northern areas raises this disease to the realm of a serious potential threat to sweetpotato production in many areas.

The development of internal cork lesions was studied. They developed in six months of warm storage at 75° F. and 90 percent relative humidity. Storage for extended periods at warm temperatures and high humidity

increased the severity of symptom expression but did not increase the number of sites. The lesions continued to enlarge through 9, 12, and 18 months of storage.

Field studies with the transmission of internal cork virus in the variety Porto Rico revealed after storage for 12 months at 75° F. and 90 percent relative humidity that from 100 hills studied, 57 showed severe symptoms in all roots, 22 showed symptoms in some roots, and 21 showed no symptoms. All plants in all 100 hills showed foliar symptoms, and this is indicative that another distinct virus may possibly be associated with internal cork.

Symptom expression of internal cork necrosis appeared, on the basis of both field and greenhouse experiments, to be a function of the amount of initial virus inoculum.

Tomato diseases. At Beltsville, Maryland, investigations are in progress on the overwintering of bacterial spot of tomato and pepper. A field plot was infested with the causal organism (*Xanthomonas vesicatoria*) in the summer. After eight months, seedlings grown in the greenhouse in soil from these plots had not developed the disease. A strain of the organism, isolated from tomato, is strongly pathogenic on tomato but produce almost no infection on pepper. Another strain, isolated from pepper, is very damaging on this host and weakly parasitic on tomatoes. Extensive greenhouse tests of supposedly contaminated seed supplied by seedsmen and canners have produced only two infected plants in 20,000.

Studies were continued with atypical strains of cucumber mosaic virus associated with a dwarfing and reduced fruit-set on tomatoes in the field. So far we have not been able to duplicate the field symptoms on tomatoes in the greenhouse.

Control of diseases in Southern plant beds. This work, terminated in 1959, was conducted at Tifton, Georgia, and vicinity to develop improved methods of controlling tomato, pepper, cabbage, onion, and sweetpotato diseases in Southern plant beds by means of fungicides, antibiotics, and chemical treatment of seed and soil. (Cooperative with the Georgia Agricultural Experiment Station and the Georgia Department of Entomology.

Investigations of means of control of bacterial spot on tomato showed no clear-cut evidence of overwintering of the causal bacterium in the soil. Excellent control was again obtained by spraying seedlings with a combination of four pounds of Tri-basic copper sulfate and 200 ppm of streptomycin.

In tests of combinations of streptomycin and fungicides for control of early blight (caused by *Alternaria solani*) of tomato the results were conflicting and at variance with those of 1957. The materials used included Zineb (Dithane Z-78 and Parzate), Maneb (Marzate) and Tri-basic copper sulfate alone and in combination with streptomycin (Phytomycin). Tests were made also with Phytoactin (TPA), Acti-dione, Amsul (ammonium ethylene bis disulfide plus manganese sulfate) and Dupont Experimental Fungicide No. 1 (1, 2-bis (ethyl sulfonyl)-1, 2-dichloroethylene). No

conclusive evidence was obtained for or against the value of combinations of streptomycin with dithiocarbamate fungicides and the other compounds showed little efficacy against *Alternaria solani*.

Shipping and handling Southern-grown plants. Tests were again made (cooperative with AMS) with shipments of tomato plants packed bare-rooted both in perforated polyethylene bags and in corrugated paper and cardboard cartons coated with polyethylene film. Shipments were made from Tifton, Georgia, to Beltsville, Maryland, and the condition of the plants indicated that the coated cartons maintained the plants in as fresh condition as did polyethylene film bags and crate-linings.

Tests on the effect of varying dilutions of gibberellic acid on seedlings in the greenhouse and field indicated that small seedlings were not sufficiently affected, under the conditions of the tests, to warrant the use of this material in production of field-grown tomato transplants.

Pepper diseases. Continued investigation indicates that certain types of pitting on pepper fruits probably are due to other causes than infection by strains of cucumber mosaic virus recovered from such fruits.

Plans: Disease investigations on the several crops and disease-causing agents will be continued for the present year along similar lines and at a level similar to that of last year except the plant bed disease studies at Tifton, Georgia, have been terminated because the objectives of the work have been very largely attained. Funds released are devoted to strengthening other disease investigations.

Publications: Bean Disease Controlled by Timely Plowing of Certain Residues. C. B. Davey and G. C. Papavizas, Crops and Soils 11: 26, 1958.

Isolation of *Rhizoctonia solani* Kuehn from Naturally Infested and Artificially Inoculated Soils. G. C. Papavizas and C. B. Davey, Plant Disease Reporter 43 (3): 404-410, 1959.

Evaluation of Various Media and Antimicrobial Agents for the Isolation of Soil Fungi. G. C. Papavizas and C. B. Davey, Soil Science 88(2): 112-117, 1959.

Effect of Organic Soil Amendments on the *Rhizoctonia* Disease of Snap Beans. C. B. Davey and G. C. Papavizas, Agronomy Journal 51: 493-496, 1959.

Investigations on the Control of the *Rhizoctonia* Disease of Snap Beans by Green Organic Amendments. G. C. Papavizas and C. B. Davey, Phytopathology 49: 525, 1959.

A New Virus Induced Streak of Pea. (Abs.) W. J. Zaunmeyer and G. Patino. Phytopath. 48: 464, 1958.

Antibiotics in the Control of Plant Diseases. W. J. Zaunmeyer. Ann. Review of Microbiology 12: 415-440, 1958.

A New Strain of Tobacco Streak Virus. (Abs.) G. Patino, Pathopath. 48: 463, 1958.

A New Strain to Tobacco Streak Virus from Peas. Graciano Patino and W. J. Zaumeyer, Phytopath. 49: 43-48, 1959.

Effect of Freezing on viability of the Lima Bean Downy Mildew Fungus (*Phytophthora phaseoli* Thaxt.) R. E. Wester, Charles Drechsler, and Hans Jorgensen. Pl. Dis. Rptr. 42: 413-415, 1958.

A New Race of *Phytophthora phaseoli* from Lima Beans. R. E. Wester and Hans Jorgensen. Pl. Dis. Rptr. 43: 184-186, 1959.

Lettuce Mosaic in Monterey County. Norman F. McCalley (with Donald L. McLean, Edward J. Ryder, and Frank W. Zink). Agric. Exten. Serv. Circ. Monterey County, Calif, 1958.

Preservation of Conidia of *Albugo occidentalis* and *Peronospora effusa*, Obligate Parasites of Spinach. M. J. O'Brien. Pl. Dis. Rptr. 42: 1312-1315, 1958.

Formation of Sporangia from Conidia and Hyphal Segments in an Indonesian *Basidiobolus*. C. Drechsler. Amer. Jour. Botany 45: 632-638, 1958.

Insects and Diseases of Vegetables in the Home Garden. L. B. Reed and S. P. Doolittle. Home and Garden Bul. No. 46. (Slight revision). 1958.

Disease of Cabbage and Related Plants. J. C. Walker, R. H. Larson, and A. L. Taylor. U. S. Dept. of Agric. Handbook. No. 144. 41 p. 1958.

Natural Transmission of Sweetpotato Feathery Mottle Virus. E. M. Hildebrand. (Abs.) Phytopath. 48: 462a, Aug. 1958.

Morning Glories as Indexing Hosts for Sweetpotato Viruses. E. M. Hildebrand. (Abs.) Phytopath. 48: 462b, Aug. 1958.

Masked Virus Infection in Plants. E. M. Hildebrand. Ann. Rev. Microbiol. 12: 441-468, Sept. 1958.

Two Syndromes Caused by Sweetpotato Viruses. E. M. Hildebrand. Sci. 128: July 25, 1958.

Aphid Transmission of a Virus Associated with Internal Cork and Masked in Feathery-Mottle Infected Sweetpotatoes. E. M. Hildebrand and F. F. Smith. Pl. Dis. Reptr., 42: 1148-1153, Oct. 15, 1958.

The Mechanism of Plant Virus Inoculation. E. M. Hildebrand. (Abs.) Phytopath. 48: 262-263, May 1958.

Some Experiments Concerned with the Formation and Inhibition of Apothecia of *Sclerotinia sclerotiorum* (Lib.). D. M. McLean, USDA, Pl. Dis. Reptr. 42(4): 409-412, April 15, 1958.

Role of Dead Flower Parts in Infection of Certain Crucifers by *Sclerotinia sclerotiorum* (Lib.) D. By., D. M. McLean, USDA Pl. Dis. Rptr. 42(5): 663-666, May 15, 1958.

10. NEMATODE CONTROL

CR

Problem: Vegetables in all parts of the country are subject to attack by a plant-parasitic nematode and the damage caused by these is often severe. The nematodes can be controlled by the use of nematode resistant vegetable varieties, by cultural practices and by chemical means, but both basic and applied research is needed to improve the present methods.

Program: A long-term continuing program of basic and applied research is in progress at Tifton, Georgia; Weslaco, Texas; and Tempe, Arizona, and a new station has recently been established at Charleston, South Carolina. Cooperation is with the Experiment Stations of the various States, and about four professional man-years are involved annually.

Progress: At Tifton, Georgia, 1,2-dibromo-3-chloropropane (DBCP) has given excellent results in nematode control for vegetables in experimental and commercial fields and a granular formulation of this material is being extensively used. Experiments have shown that this material is much less efficient when mixed with fertilizer or when applied to the surface and disked in than when applied at a depth of eight inches.

Plans: This work will be continued at about the present level.

Publications: Increase of *Belonolaimus longicaudatus* on Various Plant Species in Artificially Inoculated Soil. W. H. Lautz. Pl. Dis. Rptr. 43: 48-50. 1959.

Responses of Root-Lesion Nematodes, *Pratylenchus brachyurus* and *P. zeae*, to Various Plants and Soil Types. B. Y. Endo. Phytopathology 49(7): 417-421. 1959.

F. Insect Control

11. INSECT VECTORS OF VEGETABLE DISEASES

ENT

Problem: Expedite the solution of plant disease problems by determining the insects responsible for carrying diseases to such plants as melons, peas, and sweetpotatoes, and developing methods of preventing them from spreading the viruses or other disease-causing agents. The interactions of insects and certain viruses are known, but a large number of possible important disease insect relationships remain to be explored. Acquisition of new knowledge will contribute greatly to the development of means of avoiding or controlling the spread and severity of many economically significant disorders of plants.

Program: A long, continuing program of basic research by a team of entomologists and pathologists on the fundamental nature of the role played by insects in the spread of diseases of vegetables, supplemented by applied research on the control of the insect vectors. This work was conducted in Maryland, Arizona, Colorado, Oregon, and Washington, in cooperation with the respective experiment stations and involving about two professional Federal man-years annually, exclusive of pathological cooperation.

Progress: Recent studies in Arizona of vectors of viruses associated with the crown blight complex of cantaloup indicate that inoculation of plants with the curly top virus, even though no symptoms may be evident, may predispose plants to severe damage by later inoculations of other viruses. It seems quite logical to assume that although cantaloups are resistant to curly top after the 4-leaf stage, inoculations with some of the other viruses such as cucumber mosaic or watermelon mosaic on plants carrying the curly top virus might be disastrous. In order to further explore this field of investigation, our Phoenix laboratory is being transferred to improved facilities at the Mesa Research Station maintained by the Arizona Agricultural Experiment Station. A small ARS building and greenhouse facilities are being provided.

Field and laboratory studies in Oregon and Washington made it quite apparent that enation mosaic, a severe aphid-transmitted disease of peas, is not abundant in the major alfalfa areas of the Blue Mountain district during the spring, but is present in early pea fields. Therefore, the sources of virus lie very close to the main pea area where the most important sources are early fields of Austrian winter peas inoculated by aphid movements in early fall. It was found that these sources may be eliminated by delaying the planting of Austrian winter peas until after October 15.

In cooperative studies with Crops Research in Maryland, a virus or group of viruses causing chlorotic spotting and veinbanding symptoms in sweetpotato was transmitted to sweetpotato and to morning glory by two previously known vectors, the green peach aphid and the potato aphid, and by three new vectors, the black bean aphid, the cabbage aphid, and the foxglove aphid. The melon aphid, reported as transmitting the virus of internal cork in Louisiana did not transmit the viruses included in the present tests.

Studies of the movement of six-spotted leafhoppers (vectors of aster-yellows virus) from proven overwintering areas in parts of Missouri, Arkansas, Oklahoma, and Kansas have shown that the western edge of the migration path extends at least into Northwestern Colorado, Eastern Wyoming, and Eastern Montana. It was previously thought the western edge of this path did not extend west of Central Kansas, Central Nebraska, and North and South Dakota. The migration occurred during May and early June. This migration may be the main source of summer infestation of vegetable plantings east of the Continental Divide in these States. New host plants found in these studies for the six-spotted leafhopper include sweetpotato, watermelon, cantaloup, parsley, turnip, cabbage, artichoke, rhubarb, asparagus, and radish. It is

not yet known whether these vegetables are breeding hosts or merely feeding hosts. Relatively large numbers were taken on parsley, sweetpotato and turnips. Symptoms of aster-yellows virus were not evident on any of the 10 plants. Lists of the host plants of the virus and the leafhopper have been assembled for publication, as well as a list of other insect vectors of the virus.

Plans: Research on the role of insects as vectors of diseases of vegetables will be strengthened as rapidly as facilities permit. We plan to continue the limited work now underway on the vector relationships of virus diseases of peas, sweetpotato, and cantaloupe. It is planned to broaden the cantaloup work in Arizona to include studies of the relationship of insect vectors to cucumber mosaic, watermelon mosaic, tobacco ringspot, and curly top, relative to the so-called crown blight complex of cantaloupes.

12. INSECTS AFFECTING VEGETABLES

ENT

Problem: Insects are a limiting factor in the production of high quality vegetables. They reduce the yield, lower the quality, spread plant diseases, contaminate the marketed product, and increase the cost of production. Attempts to control them with chemicals often result in insecticide residue problems. Growers in every part of the country are concerned about how to control them more efficiently, and many are finding currently available insecticides inadequate. The general public has become greatly concerned over the hazards of insecticide residues. There is an increasing need for safe, effective, and economical methods of control that will not leave harmful insecticide residues on the marketed product nor adversely affect the flavor or quality. There is also an increasing need for methods whereby better utilization can be made of predators, parasites, and diseases of the insect pests in order to decrease the necessity for employing hazardous chemicals.

Program: A continuing long-term program of applied research supported by basic insect ecology, physiology, and pathology studies in Maryland, South Carolina, Texas, Indiana, Iowa, Ohio, Mississippi, Arizona, California, Utah, Idaho, Oregon, and Washington in cooperation with the respective experiment stations and industry and involving about 21 professional Federal man-years annually exclusive of basic work on insect physiology, insect pathology, and insecticide residues not covered in this report.

Progress: Beans. In Idaho the finding that the juice of resistant sugar beets increases the effectiveness of systemic spray to the beet leafhopper on beans provides a possible breakthrough in the long continued search for a practical chemical control for this insect. In greenhouse studies one-day old bean plants were given almost complete protection from curly top with a spray containing 0.125 percent of phorate (Thimet) and four percent of the juice of resistant sugar beets when curly-top-infective leafhoppers were caged on the test plants. The juice was not effective when used alone,

and the phorate used alone under these conditions was of little value. One theory was that the phorate, being systemic, carried the resistance factor from the beet juice into the plant. A more likely theory is that some element in the juice reacts with phorate to make it more toxic to the leafhopper. The results of these studies have raised many questions, answers to which may require a great deal of research. However, they provide a new approach in the development of control measures for the beet leafhopper-curly top complex on susceptible vegetables, such as tomatoes, beans, and melons, that cannot be grown commercially in certain areas of the Western States without frequent heavy losses.

In California, field experiments showed that a mixture of DDT and toxaphene, applied for the control of lygus bugs, kills a large proportion of the predators of lygus including Orius, Geocoris, and nabid bugs, and common spiders. DDT and toxaphene had little effect on lady beetles and lacewing larvae, but the lady beetles were affected by Trithion, ethion, and Delnav. It was also noted that Geocoris bugs were slightly affected by Thiodan and Sevin. Kelthane appeared to have little or no effect on any of the predators studied, indicating that the application of this insecticide will help rather than hinder predators in controlling the mites.

Continued research on the lygus bug problem confirmed results of previous studies, showing that two applications of toxaphene or DDT are needed, the first as soon as pods begin to form and the second two weeks later. A third application two weeks after the second was not worthwhile, although it increased the control slightly. It was also shown that the second of two applications can be delayed as much as four weeks after the first. Among the substitute materials tested, best results were obtained with dieldrin, endrin, and Thiodan. The new insecticide, Sevin, killed the adults but was not very effective against nymphs. Dipterex and Delnav also were promising. On lima beans, satisfactory control of both lygus bugs and spider mites was obtained where DDT, toxaphene, and Kelthane were used together, but where DDT and toxaphene were used without Kelthane there were more mites than on untreated beans. The yield of lima beans was increased in experimental plots by 500 to 600 pounds per acre as a result of mite control with Kelthane, and 250 to 400 pounds as a result of lygus control with DDT plus toxaphene.

Against the lima bean pod borer on heavily infested Fordhook lima beans, with three applications of spray, Sevin and endrin were the most effective materials. Endrin at one pound per acre in emulsion caused plant injury. Sevin was effective at one to two pounds per acre and was more effective in spray than in dust. Malathion, Thiodan, and dieldrin also gave promising results. Ethion, Trithion, cryolite, DDT-toxaphene, and the disease organism, usually gave only poor control.

Basic research with systemic insecticides has resulted in the development of a revolutionary method of control of spider mites on bean foliage by a simple inexpensive soil treatment. The method, still in the experimental

stage, consists of applying granular phorate, Di-Syston, or dimethoate in the seed furrow. The insecticide is dropped through nozzles or tubes attached to the planter boots so as to place the insecticide in the soil with the seed. In California tests, 1/2 pound of phorate controlled the mites for two to three months and did not leave residues in the dry beans. In field plots, 18 ounces of phorate maintained a normal yield of 21 sacks (100-pound) per acre as compared to 15 in untreated plots. Higher dosages tended to cause poor plant stands. Unlike the more costly applications of conventional insecticides to bean foliage, soil applications of systemics are not destructive to natural predators of the crop pests.

Carrots. First indications that the southern potato wireworm, the No. 1 insect enemy of potatoes in the Southeast, can damage carrots were noted when 9 percent of the carrots harvested from a planting in South Carolina were damaged by this insect. Studies on the biology and control of this insect as a pest of potatoes should be of value if control in carrot plantings become necessary. Potato growers find it necessary to use parathion or Diazinon against this pest as it is resistant to the usual insecticides applied for wireworm control such as chlordane, dieldrin, and DDT. In cooperative studies with HN the flavor of carrots grown in South Carolina in soil treated with six pounds of heptachlor or ten of chlordane per acre was not adversely affected by the insecticides. This confirms results of similar tests made of carrots grown in California in 1958 and Maryland in 1957. Turnips and parsnips were included in the earlier tests with similar results.

Cucumber. Research in South Carolina indicates that Sevin may prove to be a good replacement for lindane in the control of the pickleworm on the fall crops of cucumber, squash, and cantaloup. Lindane tends to affect the flavor of these crops and subsequent plantings of root crops in the same soil. Heretofore, attempts have failed to find effective substitutes that would neither leave undesirable residues nor cause damage.

Leafy vegetables. Efforts were continued in South Carolina to develop more satisfactory measures for control of the cabbage looper and associated caterpillar pests of cole crops. None of the materials tested gave entirely adequate control of high cabbage looper populations. The imported cabbage-worm, the diamondback moth, and the fall armyworm were more susceptible to most of the insecticides. Endrin and a mixture of parathion and toxaphene were the most effective ones, but because of residue hazards cannot be used after the appearance of portions of the plants to be eaten or marketed. Toxaphene as an emulsion spray was much more effective than as a suspension spray. Thiodan and Shell 4402 gave adequate protection against a light to moderate cabbage looper infestation, but Thiodan gave only fair control of the fall armyworm. Parathion, methyl parathion, malathion, Guthion, Diazinon, and Bayer L 13/59 showed varying degrees of toxicity to the different species. Phosdrin and Dibrom were the most promising of the insecticides that can be applied after appearance of the edible portion of the plants. Bioassay studies indicated that endrin spray residues persist on cabbage foliage in sufficient quantity to kill newly-hatched cabbage loopers as long as three weeks after an application of that insecticide.

In South Carolina, experimental applications of the spores of the bacterium, *Bacillus thuringiensis*, controlled certain of the caterpillars that attack cabbage. In small field plots of spring cabbage, six weekly applications of the spores gave adequate control of the imported cabbageworm and the diamondback moth but did not control the cabbage looper. Applications at 14-day intervals were not adequate against any of the caterpillars. A dosage of 1/2 pound per acre of dust containing 12 billion spores per gram was adequate for the imported cabbageworm when applied at weekly intervals, but one pound per acre was required for the diamondback moth. Six weekly applications of a mixture of 0.5 pound of spore material plus 1.25 pounds of malathion per acre reduced the imported cabbageworm and diamondback moth infestations by 98 percent, but gave only 51 percent reduction of the cabbage looper.

Melons. Research in Arizona during 1959 tended to confirm previous findings that curly top in cantaloup resulting from a virus transmitted by the beet leafhopper may be controlled by use of phorate treatment of the soil at planting time. This method is still experimental but may possibly be released to growers in 1960. The phorate appears to be taken up by the plants but does not persist in the older plants which are resistant to the disease. One pound of phorate in granular form is placed under the seed.

Onions. The research on the onion maggot in Washington demonstrated that much can be done toward control of the maggot by community cleanup measures to destroy its breeding and hiding places. It is especially important that cull onions not be allowed to accumulate in piles at the processing plants to provide breeding quarters. It was also found that the adults of the maggots, which are similar in many respects to the house fly but much smaller, congregate on weeds and other vegetation adjacent to onion fields and that for insecticides to be of greatest effectiveness they should not only be applied to the onion fields but also should be directed against the adults in adjacent areas.

Biological studies continued to indicate that the onion maggot is chiefly responsible for maggot damage to onions in eastern Washington. Although adults of three associated species are sometimes quite abundant they do not appear to cause much primary injury to onion. The seed-corn maggot is sometimes the most abundant but appears to feed chiefly on rotting pea vines widely used as green manure.

Sweet corn. Two sweet corn inbreds 245(9)1 and 166(11)1, developed in cooperation with the Purdue University Experiment Station, were released to breeders and producers in 1959. These inbreds have shown resistance to damage by corn earworms due to a lethal agent in the silks. Both inbreds have been selected primarily for resistance to the earworm, but due to the difference in kernel color, cannot be used in hybrid combination. Their greatest value lies in their possible use as sources of resistance in future breeding work.

Work was continued on breeding of sweet corn for resistance to European corn borer in Iowa and Ohio.

In studied to develop better chemical control methods for the corn earworm on sweet corn in Mississippi and Texas, it was found that population pressure was a very important factor. When initial infestation was two to three larvae per ear several insecticides including DDT, Sevin, Shell compound 4402 and American Cyanamid compound 18133 gave almost 100 percent worm-free ears. However, when the initial infestation was 10 to 12 larvae per ear, none of these insecticides, even with nine daily applications, gave above 40 percent worm-free ears.

Tomato. Research was continued in cooperation with the Maryland and Utah Agricultural Experiment Stations, to develop practical methods for the control of drosophila flies on tomatoes intended for processing. Under outbreak conditions, it has been extremely difficult to prevent the maggots of these insects from getting into the tomatoes without creating an insecticide residue hazard. Diazinon and malathion continued to give most promising results in experiments for the control of the insects in the field before harvest and pyrethrum after harvest. Diazinon, the most effective, was registered in 1958 for use in dusts and sprays on tomatoes up to three days before harvest but at too low a dosage of spray for adequate control. Among the experimental materials tested, the most promising were dimethoate and DDVP.

In Maryland more than 3,000 materials have been screened in the laboratory in a search for attractants for drosophila flies. None were more attractive than a mixture that has been used as a standard of comparison, which contains 10 percent of granulated sugar, one percent of apple cider vinegar, and 4 percent of Fleischmann's active dry yeast, type 1821, freshly mixed in water. Under Utah conditions, however, bait containing 30 percent of molasses, 26 percent of vinegar and 4 percent of yeast in water has continued to give best results. These mixtures are only moderately effective in the presence of natural foods of the insect. The addition of one of these attractants to insecticide sprays or granules improves the degree of drosophila control in field experiments but costs make them impractical.

Field experiment in Maryland in 1959 demonstrated that dusts containing 0.1 percent of pyrethrins in Pyrax ABB or 0.54 percent of pyrethrins plus 0.54 percent of piperonyl butoxide formulated in either Pyrax ABB or abestol superfine talc can be very effective in controlling drosophila oviposition in tomatoes during the period between harvest and processing. For most effective results the dusts should be applied to the hampers or boxes soon after harvest and extreme care must be taken that good coverage is obtained on the tomatoes throughout the container.

Plans: The above-mentioned work will be continued along the same lines.

Publications: Methoxychlor Residues on Vegetable Crops. R. L. Wallis. Jour. Econ. Ent. Vol. 52(2), pp. 232-233, Apr. 1959.

Effect of Time of Application of DDT on Lygus Bug Populations and Yield of Lima Beans. W. M. Stone and Francis Foley. Jour. Econ. Ent. 52(2), pp. 244-246, Apr. 1959.

Lindane and Aldrin Vapors in the Control of Adult Mushroom Flies. C. A. Weigel, W. N. Sullivan, I. Hornstein, and C. A. Thomas. Jour. Econ. Ent. Vol. 52(2), pp. 257-258, Apr. 1959.

Pepper Production, Disease and Insect Control. V. R. Boswell, S. P. Doolittle, L. M. Pultz, A. L. Taylor, and Roy E. Campbell. USDA FB 2051: 12-16; May 1959.

Laboratory Tests for Control of the Beet Leafhopper on Snap Beans Grown for Seed. Walter E. Peay. Jour. Econ. Ent., Vol. 52(4), 700-703, Aug. 1959.

Field Control of *Drosophila* spp. in Cull Fruit. Howard Dorst. Jour. Econ. Ent. Vol. 52(4), 755, Aug. 1959.

Fumigation Effect of Thiodan Against the Green Peach Aphid on Potatoes. Ralph Schopp and B. J. Landis. Jour. Econ. Ent. Vol. 52(4); 781-782, Aug. 1959.

Control of *Drosophila* (Vinegar Gnats) on Canning Tomatoes. Horatio Mason and Harold C. Gibson. Veg. Growers Messenger: 16. Aug-Sept. 1959.

Control *Drosophila*. H. E. Dorst. Utah Agricultural Exp. Sta. Farm & Home Sci. Vol. 20(1): 19, 24. Mar. 1959

Investigations of Insects Affecting Cantaloups. Orin A. Hills, R. W. Brubaker, and Donald L. Coudriet. Arizona Agricultural Experiment Station Rept. 180: 19-20. Dec. 1958.

Growing Lettuce in Greenhouse. Ross C. Thompson, S. P. Doolittle, and T. J. Henneberry. USDA Agricultural Handbook 149: 19-22. Nov. 1958.

Cantaloup Insects in the Southwest, How to Control Them. Orin A. Hills and Edgar A. Taylor. USDA Leaflet 389, Revised March 1959.

Insects and Diseases of Vegetables in the Home Garden. L. B. Reed and S. P. Doolittle. USDA Home and Garden Bulletin 46, Revised June 1959.

Control of Insects of Greenhouse Vegetables. Floyd F. Smith. USDA Agric. Handbook 142. January 1959.

Insecticide Recommendations of the Entomology Research Division for the Control of Insects Attacking Crops and Livestock--1959 Season. Agr. Res. Serv. and Federal Ext. Serv., USDA, Agric. Handbook No. 120: 18-51 and 58-69. Feb. 1959.

Laboratory Tests with Insecticides Against *Drosophila melanogaster*. H. E. Dorst. Jour. Econ. Ent. 52(1): 172. February 1959.

Effects of Physical Properties of Derris Dusts on their Toxicity to the Mexican Bean Beetle. F. H. Harries. Jour. Econ. Ent. Vol. 52(5): 1017. Oct. 1959.

Parasites of the European Corn Borer in the United States. W. A. Baker. 10th Int. Cong. of Ent., Vol. 4: 487. 1958.

Field Tests with the Fungus Beauveria sp. for Control of the European Corn Borer. George T. York. Iowa State Col. Jour. Sci. 33: 123-129. Nov. 1958.

Five Years of Cooperative Research on Control of the Corn Earworm in Sweet Corn. W. G. Eden and J. W. Ingram. USDA ARS-33-52. April 1959.

Control of Underground Insects on Corn. J. H. Bigger and R. A. Blanchard. Univ. of Ill. Bul. 641. April 1959.

Parasites of the European Corn Borer in Ohio. L. H. Rolston, C. R. Neiswander. K. D. Arbutnot and G. T. York. Ohio Agri. Exp. Sta. (Wooster) Res. Bul. 819. Oct. 1958.

G. Mechanization of Production and Harvesting

13. PEST CONTROL EQUIPMENT

AE

Problem: There is need for work on the reduction of cost and the improvement of effectiveness of pest and weed control equipment by the development of improved methods and equipment for use with aircraft, and surface and soil working machines.

Program: A continuing long-term program involving laboratory and field studies of equipment for control of plant diseases, insects, weeds and soil inhabiting pests by aircraft, ground, and soil working equipment, work on spray droplet sizes, and on the behavior of aerosols, was conducted with headquarters at Forest Grove, Oregon; Columbia, Missouri; St. Paul, Minnesota; Toledo, Ohio; Beltsville, Maryland; and Ames, Iowa, in cooperation with State Agricultural Experiment Stations of Washington, Oregon, Missouri, Minnesota, Ohio, and Iowa, involving about seven professional Federal man-years annually.

Progress: Aircraft Application on low growing crops. Spray deposit pattern studies were continued for low flight levels using agricultural aircraft of different types to determine the effect of nozzle placement, speed, height of flight, and use of extended flaps on the deposit patterns produced. The basic pattern produced by spray delivered from each one-foot interval of boom segment on a Rawdon T-1 airplane was determined. With uniform nozzle spacing the use of flaps did not affect the pattern from Rawdon T-1. Distribution from uniform nozzle spacing was not as good from this aircraft as from N3N or Stearman aircraft with similar equipment and operating

conditions. The AG-2 Transland gave good spray distribution over 80 feet with or without flaps at low flight elevation and over 115 feet at flight heights of 25 feet or over.

Excellent control of green peach aphid on potatoes was obtained from eight aircraft spray applications made at weekly intervals beginning when aphids first appeared. Control was effective in winds up to eight miles per hour. Spray applied at ten gallons per acre was more effective in aphid control than when applied at five gallons per acre.

Control of soil inhabiting pests. A considerable number of different fungicides, insecticides, and herbicides were applied to muck, loam, and sandy soils where vegetables, forest tree seedlings, nursery stock, and ornamentals were to be grown. A rotary tiller, modified to treat rows, was used. A field cultivator with coiled shank type of tooth and back-swept knives was also assembled for row treatments. In order to facilitate the handling of chloropicrin in shipping containers, a hinged cradle clamp mounted on the field cultivator applicator was constructed and found to be quite useful. In order to improve the convenience and certainty of its application, the addition of a dye to this material was found to make its presence in liquid form more readily visible. A number of methods for sealing the surface to retain volatile materials were tested. These included water seal, drags, or rakes to smooth the surface and polyethylene film cover.

Applications of DD soil fumigant to investigate the possibility of Golden nematode eradication were made to plots on Long Island, New York, where potatoes are to be grown. The applications were made with a chisel type applicator with points spaced at 10-inch intervals. Applications were made without mechanical difficulty but results will not be known until next season.

Spray equipment for control of insects and diseases by ground machines. Experiments were designed to study the effectiveness of air blast sprayers in the control of foliage and fruit diseases of canning tomatoes. An experimental machine capable of uniform distribution of sprays was used for comparisons of applications at 10, 20, and 40 gallons per acre over a 36-foot swath. Air volume delivered was approximately 24,000 cubic feet and maximum velocity at the outlet was 90 to 100 miles per hour. The air pattern was distributed so that velocity at the plants was low enough to avoid any damage. Late blight, one of the most difficult to control foliage diseases of tomatoes, was in epidemic proportions in the test area. Maneb wettable powder fungicide at three pounds per acre rate was applied in all comparative treatments. The late blight infection of over 70 percent in the untreated check plots was reduced to less than two percent with air blast applications of 10, 20, or 40 gallons of spray per acre. The results when the spray material was introduced into the air stream at 60 psi were as good or better than at 300 psi. Air blast applications at 10 to 40 gallons per acre were equally effective or better

than hydraulic spray applied at 160 gallons per acre and 300 psi. The net yield of tomatoes averaged 19.2 tons per acre for the air blast sprayed plots and only 1.9 tons per acre for the untreated check plots. The percentage of control of anthracnose disease, which was also present on the experimental plots, was 82 percent with the air blast sprayer using 10 to 40 gallons of spray per acre. This was slightly better control than hydraulic spray at 160 gallons per acre and 300 psi.

Using a special row-crop sprayer and duster developed previously for the control of the green peach aphid, the effectiveness of different methods of applying sprays was compared. Overhead nozzles alone were not found to be effective. Oil burner nozzles spraying into an air stream were not as effective as spray from hollow cone nozzles delivered from the same location. The best control was obtained from a combination of flat spray nozzles mounted overhead and hollow cone nozzles mounted laterally and directed upward at an angle for underleaf coverage. No arrangements of spray nozzles thus far tested is fully satisfactory for controlling populations of the aphids at the top and middle foliage levels.

Hydraulic spray equipment was used in corn earworm field experiments on sweet corn. A major requirement in earworm control is frequent and thorough coverage of the silk during the silking period with a suitable insecticide. Five spray applications were made at two-day intervals starting with 50 percent of the ear shoots showing silks. Two nozzles per row, one on each side gave excellent coverage of the silk zone when applying 30 gallons per acre at 40 psi.

Weed control in row crops. A study was conducted to evaluate equipment and methods for applying granular herbicides. Working 2,4-D granules into the soil had little effect on the control obtained. Early post-emergence applications of granular 2,4-D to corn gave excellent control and no crop damage at pre-emergence rates. The effect on weed control from nonuniformity of application of granular herbicide in over-the-row bands was not found to be significant.

A study of the possibility of automatic steering of tractors to improve accuracy of cultivation was begun. Automatic tractor steering was mathematically analyzed to see if simple control systems would be stable. It was found that a contractor type hydraulic control system could be stabilized if velocity feedback was used. The performance of such a control system was simulated with an analog computer to confirm the analysis. A control system was constructed on a tractor to be used in field tests, but was not completed in time to be used this season.

Spray atomization and relation to pest control. Since it has been found that degree of spray atomization is an important factor in control of certain insects, techniques for determining atomization have been improved. A method was developed for estimating in the field the mass median diameter of a spray sample by measuring the five largest spots it produces on a dyed

paper card. This was made possible by more accurate spread factor determinations and by correlation of the mass median diameter to the largest drop diameter.

The objective of this study is to determine whether results obtained by application of pesticide sprays are affected by the drop size of the spray pattern. Sprays of controlled mass median diameter and containing a fungicide were applied to randomized plots of tomatoes. The effect of the treatments was measured by the amount of defoliation, early blight, late blight, anthracnose, and yield of fruit observed in each group of plots. Flat or hollow cone nozzles were used and mass median diameters of the spray were varied from 200 to 500 microns in steps of 100 microns for each type of spray pattern. Reduced concentrations of fungicide were used to intensify differences which might occur in disease control. A series of drop size ranges were applied at a rate of 40 gallons per acre for both types of spray pattern, and at 20 gallons per acre using the flat pattern nozzles only. The results indicated the spray treatments were capable of controlling the disease observed but that no significant differences which could be attributed to type of spray nozzle used or drop size of the spray applied.

Small particle behavior. A study was continued to provide basic theoretical concepts and experimental data needed for development of pesticide application equipment and techniques which have optimum depositing efficiency and distribution characteristics. Considerable progress was made in describing the behavior of groups of small particles mathematically. Because of the effect of particles upon each other, it has been found that behavior of groups of particles cannot easily be predicted from the behavior of single particles. A formula similar to those describing flow of fluids has been developed which describes the behavior of groups of small particles.

Plans: Further work will attempt to improve uniformity of spray deposit pattern from high and low flying aircraft. Field experiments on corn borer control, emphasizing granular applications and air blast sprayer equipment, will be continued. Distribution of air and spray patterns will be improved in air blast sprayers, and higher concentrations of pesticides will be tried. Improved equipment for cultivation and for application of granular and spray herbicides will be tested. Economic analysis of a number of weed control methods will continue, and study of small particle behavior will be extended.

Publications: Distribution of Insecticides from Fixed Wing Aircraft and Ground Power Equipment with Special Reference to Physical and Biological Factors. J. C. Chamberlin and V. D. Young. Proc. 10th Internatl. Congress of Entomology, Vol. 3, 1956 (1958). pp. 255-260.

Aerial Equipment. V. D. Young, J. C. Chamberlin. Agricul. Handbook, Wash. Agricul. Exp. Sta., Inst. of Agricul. Sci., State Col. of Wash., pp. 40-52. (1958).

Control of the Green Peach Aphid on Potatoes by Means of Aircraft and Improved Ground Equipment. J. C. Chamberlin, Calvin E. Doonier, C. W. Getzendaner, Ent. Res. Div., and V. D. Young, Agric. Eng. Res. Div. ARS, USDA, Forest Grove. Ore. Abs. of 18th An. Pacific Northwest Veg. Insect Conf. Portland, Ore., Jan. 1959. p. 18-19.

Statistics in Residue Studies. W. F. Kwolek, J. E. Fahey, W. G. Lovely, and M. L. Fairchild. Proc. 13th An. Metg., North Central Branch Ent. Soc. America, 13:78.

Evaluation of Insecticides for European Corn Borer Control in 1957. M. L. Fairchild and W. G. Lovely. Proc. 13th An. Mtg. North Central Branch Ent. Soc. of America. 13:55-56.

Test Granular Insecticides for Corn Borer Control. W. G. Lovely, J. E. Fahey, H. C. Cos, M. L. Fairchild, and J. A. Harding. An. Rept. of Div. of Agriculture, Iowa State College, Ames) 1957-58, p. 51.

Control of the Cabbage Looper on Broccoli. Jos. C. Chamberlin, Calvin E. Doonier, C. W. Getzendaner, and V. D. Young. Abs. of 18th An. Pacific Northwest Vegetable Insect Conference, Portland, Ore.

Spray Atomization and Deposit Pattern Tests of Airplanes Used for Spruce Budworm Control. D. A. Isler and Bohdan Maksymiuk. Special Rept. by 58-3, Beltsville Forest Insect Laboratory, Beltsville, Md., Oct. 1958.

Thimet Provides Built-in Protection Against Potato Leafhopper. J. P. Slesman and Ovre K. Hedden. Ohio Farm and Home Research Vol. 43, No. 312, May-June 1958, published by Ohio Agricultural Experiment Station, Wooster, Ohio, p. 39.

H. Economics of Production

14. ANALYSIS OF FARM COSTS

FE

Problem: Farmers, research workers, and commodity analysts need more information on production costs in order to ascertain the effects of new technology on returns and on comparative advantage among producing regions. Growers and employment agencies need up-to-date labor requirement information in order to plan for recruitment and placement, and the USDA needs cost and labor information to improve its statistical series on farm labor requirements and productivity.

Program: A survey for the year 1959 is being made of production practices, labor requirements and costs of producing the major truck crops in the following counties: Erie, New York; Accomack and Northampton, Virginia; Colquett, Georgia; Broward and Palm Beach, Florida; Cameron and Hidalgo, Texas; Berrien and Van Buren, Michigan; Columbia, Wisconsin; Yakima, Washington; Marion, Oregon; and Imperial, Monterey, and San Joaquin,

California. This is one part of a continuing national study of changes in farm production practices and costs for major farm commodities. The truck crop survey is being made under contract by Crossley, S-D Surveys, Inc., of New York. About one Federal man-year will be involved.

Progress: The survey of truck crop producers is just getting under way.

Plans: The survey will be completed in the spring of 1960. It is planned to prepare statistical tables showing for each area operations performed, equipment used, and labor and material requirements.

II. UTILIZATION RESEARCH

A. Chemical Composition and Physical Properties

1. CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES OF VEGETABLES WU, EU, SU

Problem: Inadequate information regarding the chemical composition and physical properties of vegetables is impeding research toward improvement of processing methods, and development of new and improved products.

Program: A continuing long-term program of fundamental and applied research involving eight professional Federal man-years per year, and two professional industry-sponsored man-years per year is being conducted at Albany and Pasadena, California; Wyndmoor, Pennsylvania, and Winter Haven, Florida, in cooperation with U. S. Plant, Soil, and Nutrition Laboratory at Ithaca, New York, and under contract at the University of Idaho, Moscow, Idaho; on the relationships of chemical composition to time required for cooking of several types of dry beans; Stanford Research Institute, Menlo Park, California, on development of laboratory methods for evaluating dry beans; and at the University of Illinois, Urbana, Illinois, on the relationship of processing methods to characteristics of dry bean products. The National Cannery Association, Washington, D. C., and the California Lima Bean Advisory Board, Los Angeles, California, are each sponsoring one professional worker.

Progress: Digestibility studies on dry beans. Test tube studies at WU on digestibility of starch in cooked beans were reported previously on the California small white variety. It was found that the starch was resistant to enzymic digestion unless some means were taken to rupture the bean tissue cells prior to cooking. If the cells were ruptured, starch was as easily digested as purified starch isolated from several sources including beans, wheat, and potatoes. Three additional varieties tested gave the same results, indicating that resistance to digestibility of starch in intact cells is a common property of all beans. Furthermore, studies of the effect of acidity on starch digestibility indicated that modification toward conditions more acid or more alkaline than normal in soaked beans decreased the digestibility.

From the large bowels of guinea pigs, entrapped starch that was not freed from intact tissue cells, could be observed under a microscope when the animals had been fed cooked whole beans. Thus, resistance to digestion by enzymes that would have been encountered in the mouth, stomach, and small intestines was observed.

It was not possible to observe visually whether or not an equivalent amount of undigested starch passed into the large bowels of animals fed beans that had been slurried prior to cooking so that the starch was free. However, quantitative determinations of undigested starch in the solids recovered from the bowels of animals fed either beans cooked whole, or raw-slurried and cooked, indicated that no differences could be attributed to the method of preparing the bean samples that were fed to the animals. Thus, for reasons as yet unknown, these in vivo data do not agree with those from the test tube studies.

Work was extended to a study of the fermentation rate, immediately after sacrifice, in the excised large bowels of animals fed bean and control diets. Average results from preliminary studies were inconclusive as to differences between the two diets. However, all of the very high values for rate of gas formation were in the bean diet group. This indicates that under certain conditions a bean diet can be a source of excessive gas formation by fermentation in guinea pig intestines.

Factors affecting cookability of dry beans. Contract studies at the University of Idaho have been initiated on the relationship of chemical composition to time required for cooking several types of dry beans. Eight lots of legume seeds including four varieties of common beans, lima beans, black-eye beans, fava beans, and dry peas were procured and preliminary separations and component analyses were made. Protein content ranged from 23.0 to 28.2 percent among the common bean lots while it ranged from 23.5 to 29.2 in the other legumes. It cannot be concluded that protein content differences are related to generic differences within the samples of this study. However, there is some indication that fava and blackeye beans and peas are higher in protein than lima, Great Northern, Red and Pinto beans; only the one lot of Michigan-grown Michelite beans was found to be in the higher range.

An investigation of the effect of calcium and calcium-sequestering compounds on the cooking rate of dry beans has been initiated. A device has been constructed to measure objectively, the time required to cook dry beans.

Histological studies have been initiated to learn what and how components of beans change during maturation from the green, succulent, easy-to-cook stage to the dry bean that may take an hour or more to cook.

Dry lima beans. Investigations at WU on the chemical composition of large, white-dry lima beans have continued, with particular emphasis on the characterization of the nitrogenous constituents. It is anticipated that these studies may facilitate the development of satisfactory procedures for the preparation of new and improved products from surplus beans.

Through cooperation with the University of California, South Coast Field Station, Irvine, California, it has been possible to obtain an annual supply of uniform, genetically homogeneous, dry lima beans which have been grown in the same environment from year to year. Since biological variations may be expected to be minimized under these conditions, the results of chemical studies should have greater significance than those conducted with material of unknown character and genetic history. Proximate chemical analyses will be conducted annually for the purpose of characterizing the general composition of these beans, and to establish the extent of variability in composition that may be expected as a function of seasonal variations.

Analyses have been completed on dry lima beans obtained from the 1958 crop. These included dry, immature green beans, and dry, mature white beans and their component parts such as the seed coat, cotyledons, epicotyl and hypocotyl. These products were analyzed for total nitrogen (protein equivalent), total sugars, reducing sugars, moisture, ash, sulfur, and fiber. A number

of unknown nitrogen compounds were detected but have not yet been identified. Free amino acids and other nitrogenous compounds have been identified and compared in lima beans harvested at different stages of maturity to ascertain the nature of the biochemical processes which produce the edible form.

On the premise that fresh, green lima beans do not produce the same type or degree of gastrointestinal distress commonly associated with dry beans, work has been initiated to determine chemical differences between green beans and dry beans.

Animal feeding studies will continue with immediate efforts on improvement of experimental techniques in the starch digestibility investigations and extension of the study of effects of dry bean saponin on intestinal irritation and gas formation. The research on indirect measurement of flatulence in human beings will be completed during the next year and important results introduced into other projects on dry beans.

Chemical basis of vegetable flavors. There is a lack of knowledge of the chemistry of vegetable flavor. This knowledge is necessary for the processing of vegetable products in order to obtain truly precise objective analyses of flavor. Such analytical methods for flavor determination will be useful for selecting raw material for processing, for studying processing conditions to preserve flavor and to minimize off-flavor development, and for evaluating the final processed vegetable product. Part of the work at WU is being supported by industry.

Investigation of the breakdown of methionine, an essential sulfur-containing amino acid, by cabbage enzymes is in progress. A new enzyme has been discovered which will decarboxylate methionine, removing the carboxyl group as carbon dioxide. The other product has not been identified but is believed to be the amine, 3-methylthiopropylamine. It has also been discovered that methionine is degraded non-enzymatically in the presence of ferrous ion, a chelating agent, and oxygen. Again the carboxyl group is removed as carbon dioxide but the identity of the other product, which is highly odoriferous, has not yet been established.

The volatile carbonyl components from onions have been studied. The presence of six aldehydes and ketones have been demonstrated and the identity of five of these established: acetaldehyde, acetone, propionaldehyde, methyl ethyl ketone, and n-butyraldehyde.

The chromatographic separation of thiolsulfinates, which occur in freshly cut garlic and probably onion, is being investigated. A colorimetric reagent has been discovered which will distinguish thiolsulfinates from disulfides and thiolsulfonates, either in test tubes or on paper chromatograms. Further progress in this field is absolutely dependent on this newly-discovered technique.

Acetoin, believed to be an important flavor component, has been quantitatively determined in peas, corn, spinach, beets, and asparagus. The acetoin content of blanched, frozen, peas increases with heating. Model studies

indicate that the increase is due to a non-enzymatic reaction wherein pyruvic acid is catalyzed by thiamine (Vitamin B₁).

Rapid, semi-quantitative, methods have been developed for the analysis of volatile aldehydes, ketones, and acids. These potential flavor factors are isolated as solid derivatives, exchanged rapidly with regeneration reagents, and flashed directly into a gas chromatography instrument for separation and identification.

Nitrogenous constituents of cabbage and kidney beans. The soluble nitrogen constituents of cabbage have been identified and determined quantitatively at EU. The insoluble constituents were investigated in a preliminary manner by solubility tests, paper electrophoresis, and protein precipitation methods. Studies on the soluble nitrogen constituents have been summarized in two manuscripts which have been accepted for publication.

Quantitative studies on the soluble nitrogen constituents of the kidney bean have shown that 8.3 percent of the total nitrogen is extractable with aqueous ethanol. Gamma-L-glutamyl-S-methyl-L-cysteine, its sulfoxide, and S-methyl-L-cysteine account for much of the soluble nitrogen. Current investigations have been concerned with derivatives of S-methyl-L-cysteine and with the development of a quantitative method for the determination of pyrrolidone carboxylic acid.

Celery flavor components. In initial work at SU, the problem was divided into two phases, volatile compounds and nonvolatile compounds. The former of these classifications appears to account for most of the characteristic flavor in celery. The following findings indicate the complexity of the problem: (1) At least 20 to 25 steam-distillable compounds are present; but it is not yet known how many of them contribute to the flavor or odor. (2) At least five of the constituents are retained by the pulp when the juice is expressed. (3) The compounds are, in the main, highly volatile, requiring, in some cases, liquid nitrogen temperatures for condensation. (4) The compounds are present in minute concentration, necessitating the use of large quantities of starting material and the application of microanalytical methods.

The juice from approximately 1-1/2 tons of celery was distilled in a pilot-plant essence recovery unit and volatile materials collected in traps cooled to different levels of low temperature. Investigation of the dry ice-acetone condensate, which consisted of two phases--an emulsion and a clear oil--revealed that the oil was at least 90 percent d-limonene.

Plans: Compositional studies at WU will be continued at approximately the present level on numerous varieties of dry beans and on vegetables in general particularly with respect to flavor components. Studies on the nitrogenous constituents of cabbage at EU have been completed. Work on the nitrogenous constituents of kidney beans will be concluded at an early date.

The work on celery flavor components at SU, is being continued, with major effort in the early future concentrated on isolation and identification of celery constituents responsible for the characteristic flavor and odor of the crop, and on determination of the effects on these constituents of variety, cultural conditions, and postharvest treatment.

Publications: Enzymatic Formation of Reducing Metabolites by Slices of Plant Tissue. R. U. Makower. (Abt.) Fed. Proc. 18 (1) 1959.

Microscopic Identification of Microgram Quantities of Galacturonic Acid and Glucuronolactone. Direct Synthesis of Hydrazone Derivatives by Solvent Diffusion Technique. L. M. White and G. E. Secor. Anal. Chem. 31, 1273-1274. 1959.

Note on the Use of Detergents for Removal of Nitrogen from Plant Materials. A. Bevenue and K. T. Williams. J. Assoc. Official Agr. Chem. 42, 441-444. 1959.

Carbohydrate Studies of the Lima Bean. K. T. Williams and A. Bevenue. J. Assoc. Official Agr. Chem. 42, 822-827. 1958.

Evaluation of Yield and Quality in Relation to Harvest Time of Lima Beans Grown for Processing in Utah. K. D. Salunke, L. H. Pollard, E. B. Wilcox, and H. K. Burr. Bul. 407, Utah State Agric. Exp. Sta. 1959.

Theoretical Curves for Variably Loaded Countercurrent Distributions from Tables of the Cumulative Binomial. G. Alderton. Anal. Chem. 31 (4) 625. 1959.

Determination of Sorbic Acid and Its Disappearance from Pickle Brines. G. Alderton and J. C. Lewis. Food Research, 23, 338-344. 1958.

Separation of Aliphatic Disulfides and Trisulfides by Gas-Liquid Partition Chromatography. J. F. Carson and F. F. Wong. J. Org. Chem. 24, 175. 1959.

A New Colour Reaction for Thiolsulphinates. J. F. Carson and F. F. Wong. Nature 183, 1673. 1959.

Enzymatic Degradation of Adenosine Triphosphate to Adenine by Cabbage Leaf Preparations. M. Mazelis. Plant Physiol. 34, (2) 153-158. 1959

Nonenzymatic Formation of Acetoin in Canned Vegetables. J. W. Ralls. J. Ag. Food Chem. 7, 505. 1959.

Unsymmetrical 1,6-Additions to Conjugated Systems. J. W. Ralls. Chem. Reviews 59 (2) 329-344. 1959.

The Reaction of Triphenylphosphine, Triphenylarsine, and Triphenylstibine with Thiolsulfinates. J. Carson and F. F. Wong. Am. Chem. Soc. Mtg. Sept. 1959, Abstract. Abstracts of Papers, page 99P.

The Isolation and Characterization of γ -L-Glutamyl-S-Methyl-L-Cysteine from Kidney Beans (*Phaseolus vulgaris*). R. M. Zacharius, C. J. Morris, and J. F. Thompson. Archives of Biochemistry and Biophysics 80, 199. Jan. 1959.

High Viscosity of Cell Wall Suspension Prepared from Tomato Juice. R. T. Whittenberger and G. C. Nutting. Food Technology 12, 420-4. 1958.

2. CHEMICAL ATTRACTANTS FOR DROSOPHILA

WU

Problem: Drosophila (fruit fly) infestations are a serious problem to many vegetable processors, particularly those engaged in processing tomatoes. In some cases, products are judged to be unfit for human consumption due to contamination due to Drosophila, and this results in a loss to the processor and the grower.

Program: A program of research on the composition of materials that are attractants to Drosophila was recently initiated, involving one Federal professional man-year per year. Materials concentrated or isolated during this work will be provided to entomologists in other USDA agencies for further testing and for incorporation into more effective baits or "super-attractants" to be used in control of Drosophila in the field and in processing plants.

Progress: The early phases of the work have shown that certain stages of a normal alcoholic ferment may be more attractive to Drosophila than other stages. No definitive results are as yet at hand.

Plans. Work on the chemistry of Drosophila attractants will be continued at the present level and in cooperation with other USDA agencies.

B. New and Improved Food Products and Processing Technology

3. NEW AND IMPROVED PROCESSED PRODUCTS FROM SWEETPOTATOES

SU, EU

Problem: Increase the utilization of sweetpotatoes through improvement in quality of existing products and development of new and improved products.

Program: A continuing long-term program involving chemical, physical, and engineering studies in the laboratory and pilot plant; carried out at the Southern Regional Research Laboratory, New Orleans, Louisiana, in cooperation with the Louisiana Agricultural Experiment Station and the Quarter-master Food and Container Institute for the Armed Services; involving about three professional Federal man-years annually, of which about one man-year is paid by QMF-CI funds.

The development of a process to make satisfactory dehydrated mashed sweetpotatoes in flake form from Eastern-grown (dry type) sweetpotatoes is being conducted at the Eastern Regional Research Laboratory and involves one professional man-year annually.

Progress: Precooked dehydrated sweetpotato flakes. Preliminary pilot plant research on the drum drying of mashed Eastern dry-type sweetpotatoes has been initiated at EU. The effects of drum speed and drum temperature on mash pickup rate, evaporation rate and production rate have been determined. At drum speeds optimum for drying mashed white potatoes, much lower production rates are obtained with mashed sweetpotatoes. For example, product output from the single-drum drier was about 12 pounds per hour with sweetpotato as compared with about 50 pounds per hour with white potato mash of the same solids content. This is due to the much poorer adherence of the sweetpotato mash to the drum. Because of the poor adherence, a low density sheet is obtained from which water is more easily evaporated. It may be possible, therefore, to increase output by running at higher drum speeds and still obtain flakes of satisfactorily low moisture content.

While it has been shown that the single-drum drier is more efficient for drying mashed white potatoes (because of the multiple applications of mash) there is some indication that the double-drum drier is more efficient for mashed sweetpotatoes.

In-process treatments of the potato, such as precooking in water at about 160° F., dilution of mash, and incorporation of emulsifiers (known to improve white potato mash quality) have been studied in a preliminary manner. Sweetpotato flakes containing antioxidant have been packed in air and in nitrogen atmospheres and are being stored to test their keeping quality.

Substantial progress was made at SU in continued work on production of pre-cooked dehydrated sweetpotato flakes by a process similar to that developed by the Eastern Utilization Research and Development Division for white potatoes. Such a product from southern-grown sweetpotatoes, which will have good flavor and long shelflife, and will readily take up hot water to form a smooth puree, will greatly aid in the development of the Armed Forces' simplified logistic ration. At the same time it will provide a convenience food for domestic use and will afford a profitable outlet for a substantial proportion of the sweetpotato crop which commonly has not hitherto brought a satisfactory return to the grower.

Experimental batches of flakes prepared in a small scale pilot plant have now been produced which have remained flavor-stable for over 200 days and are still on test. The storage stability was greatly improved by addition to the cooked and pureed sweetpotatoes, before drum-drying, of a suitable antioxidant. Flakes so prepared from both Unit I Porto Rico and Goldrush varieties have remained flavor-stable for over six months and apparently will retain an acceptable taste for an indefinite period. Very little loss of carotene (Provitamin A) has been experienced during processing or storage.

Frozen French fried sweetpotatoes. Studies were continued on the preparation of frozen French fried sweetpotatoes at EU using mostly eastern dry-type tubers from the 1958 crop. Data on piece size, time and temperature of frying, and time and temperature of heating before served were determined.

Storage studies indicated that samples prepared under optimum conditions and stored for one year could not be distinguished in texture and flavor from freshly prepared samples.

Arkansas Frozen Foods, Inc , Little Rock, Arkansas, recently introduced French fried yams under the Lido label.

Plans: Work on frozen French fried sweetpotatoes will be completed with the preparation and evaluation of samples from the 1959 crop. Pilot plant research will be continued at EU on eastern dry-type sweetpotatoes to determine whether through further in-process modifications of the potato and/or through equipment changes, the single-drum drier can be used efficiently in drying them. Further study of keeping quality of the dried flakes will be made.

Work is being expanded and accelerated at SU to carry experimental production of sweetpotato flakes to semi-commercial pilot-plant scale; to expedite full solution of the stability problem; determine the equipment and processing conditions most suitable and economical for commercial operation; produce sufficient quantities of the product for adequate evaluation of its acceptability for military rations and civilian consumer use; and appraise commercial manufacturing costs.

4. TIME-TEMPERATURE TOLERANCE OF FROZEN VEGETABLE PRODUCTS

WU

Problem: A continuing program of basic and applied research involving three professional Federal man-years per year is being conducted at Albany, California, and in cooperation with individual food packers and trade associations (i.e. National Association of Frozen Food Processors, Northwest Cannery and Freezers and Western Frozen Food Processors, Refrigeration Research Foundation, The California Farm Bureau Federation, Agricultural Extension Service and others).

Progress: Time-temperature tolerance of frozen vegetables. Investigations have continued on the effects of time and temperature on the stability of frozen cauliflower and spinach in order to provide information needed as a basis for the development of improved processing procedures.

Data resulting from work completed in previous years on frozen peas and green beans, including studies on microbial populations of vegetables, was prepared for publication.

In general, it was found that chlorophyll deterioration in spinach occurred at a rate intermediate between the rates for peas and green beans. Correlations were drawn between the difference in level of chlorophyll retention of samples of frozen spinach and subjective evaluations of flavor and color of the same samples. When the chlorophyll difference was 2 percent or greater for spinach samples, a significant percentage of the panel could detect a color change (for peas the value was 1.5 percent; and beans, 4 percent). For frozen spinach, the rates of color and flavor deterioration were similar. In this respect, they followed the pattern observed with frozen peas and contrasted with green beans, in which color deterioration was considerably more rapid than flavor deterioration.

These studies have shown, as have those on other commodities in these investigations, that degradative changes occur in frozen foods without reversal, and that rates are influenced strongly by temperature. The quality change with each abusive temperature treatment is cumulative: subsequent temperature reduction below zero will not reverse any damage but only slow down the rate of the inevitable quality deterioration. Fluctuations of temperature do not, in themselves, have a specific adverse effect on quality. The deterioration that occurs is the sum of each increment of time-temperature damage in any temperature cycle.

Cauliflower has been observed to develop a characteristic tan color as a result of time-temperature abuse. This color change can be measured by the amount of pigment soluble in a 2 percent acetone extract. Effective laboratory techniques have been developed to reduce the turbidity of this extract and provide more sensitive data for study of this phenomena.

In general, cauliflower exhibits this discoloration at a rate dependent upon temperature. An important, but not fully understood, exception was the first lot of March variety of cauliflower in this study. This led to a provisional assumption that the variety was important in respect to discoloration rate. Current information does not sustain this hypothesis and the rapid deterioration of that lot remains an enigma.

Effect of light on frozen peas in transparent packages. As an extension to the studies on TTT of frozen foods designed to provide data necessary for improved processing, an experiment was run on the stability of frozen foods to light. Frozen peas in polyethylene bags were exposed to the illumination of two 20-watt fluorescent lights at a distance of 21 inches. Exposures were made at two temperatures, 0° F. and 20° F.; dark controls were used in each instance. Exposure of a large portion of the surface was attained by using flat packages and mixing the contents daily. Difference in color between illuminated samples and dark controls were noted in four days at plus 20° F. and in three weeks at 0° F. Flavor changes were detected after one week at plus 20° F. No flavor difference was detected between illuminated samples and dark controls at 0° F. over a four-week period. The subjective evaluations of color change were substantiated by objective measurements of color and chlorophyll content. Frost formation was found to be faster in illuminated samples than in those stored in the dark.

Plans: Data on cauliflower and spinach will be published during the next year and dissemination of all time-temperature tolerance information to the industry will continue.

No further work is anticipated on the effect of light on frozen vegetables in transparent packages.

Publications: Determination of the Conversion of Chlorophyll to Pheophytin. W. C. Dietrich. Food Technol. XII, 428. 1958.

Time-Temperature Tolerance of Frozen Foods. XVI. Quality Retention of Frozen Green Snap Beans in Retail Packages. W. C. Dietrich, M. F. Nutting, R. L. Olson, F. E. Lindquist, M. M. Boggs, G. S. Bohart, H. J. Neumann, and H. J. Morris. Food Technol. XIII (2) 136-145. 1959.

Time-Temperature Tolerance of Frozen Foods XVIII. Effects of Blanching Conditions on Color Stability of Frozen Beans. W. C. Dietrich, R. L. Olson, M. F. Nutting, H. J. Neumann, and M. M. Boggs. Food Technol. XIII, 258. 1959.

Time-Temperature Tolerance of Frozen Foods. Quality Changes in Frozen Spinach Stored in Retail Packages. W. C. Dietrich, M. M. Boggs, M. F. Nutting, and N. E. Weinstein. Food Technol. XIII, Abstracts. Page 34. 1959.

Effect of Illumination upon Color of Frozen Peas Packages in Transparent Films. A. D. Shepherd. Food Technol. XIII, 539. 1959.

5. IMPROVED PROCESSING METHODS

WU, EU, SU

Problem: In order for vegetables to compete with other food items, it is essential that the quality of processed products be improved and that new easy -to-prepare products be developed.

Program: A continuing long-term program of both basic and applied research at Albany, California; Wyndmoor, Pennsylvania; and Weslaco, Texas, involving four professional Federal man-years per year is being conducted in cooperation with interested industrial groups and research organizations. A cooperative study is under way at Brigham Young University on analytical procedures for measuring chlorophyll and its conversion to pheophytin. Part of the research was financially supported through the Quartermaster Food and Container Institute, Chicago, Illinois.

Progress: Tomato juice powders. By informal cooperation with the Thornton Canning Company, experiments were carried out on commercial scale equipment to determine effects of pretreatment of tomato macerates on composition and physical properties of expressed tomato juice. Cooperation has been maintained with the same company in their continued efforts to develop on a commercial scale the continuous vacuum drying of tomato juice powder.

Samples were obtained under commercial processing conditions intended to show the effects on tomato juice viscosity of "low temperature" holding of tomato macerate prior to heat treatment. As carefully controlled as possible under the conditions of operation (about 80 tons of tomatoes were being crushed per hour at the time of the experiment), the results indicated differences in raw material that were so great as to overwhelm most of the differences in products due to processing. Some viscosity decrease was related to the "cold break" process, as would be expected if the treatment was too severe. On the other hand, the process used was specified to reproduce conditions which have been described in recent literature to cause an increase in viscosity over the regular "hot break" juice or concentrate. Lack of raw material control in such operations discourages further work on such a scale.

Investigations related to the foam stability of tomato juice concentrate for vacuum puff drying led to a new process, called "form-mat" drying, which does not require vacuum procedures.

In foam-mat drying, an edible stabilizer, such as a monoglyceride, is added to a tomato paste which is then foamed by beating in air. The resulting stiff foam is spread on a tray or belt and is dried in a warm air stream. The product is a dry foam which can be compressed to a fairly dense powder for packing.

Foam-mat powders have been produced from tomato paste, as well as from orange concentrate, concentrated whole milk, coffee extract, sugar-pectin mixtures, and other materials. All of these powders can be readily reconstituted in cold water by spoon stirring. Their initial quality is high.

Chemical analyses of tomato powder produced by this process in preliminary testing indicated only a 10 percent loss in reduced ascorbic acid. Redness and consistency are very good in the reconstituted paste. This process shows promise of being workable and inexpensive on a commercial scale.

Dehydrofreezing of vegetables. Industrial development of the dehydro-freezing of vegetables, and related problems of selection of raw material and control of processing operations, has continued in field and laboratory investigations. Active cooperation has continued with Spiegl Farms and Gerber Products Company on problems related to evaluation of maturity of seed type vegetables. Preliminary data indicate the usefulness of the Shear Press for predicting harvest date for processed Fordhook lima beans, and will help guide future investigations on baby limas and peas.

Control of the dehydration step in dehydrofreezing is dependent upon uniformity of raw material. Objective measurements of biological maturity by use of the Shear Press have provided good correlation values (.91 to .94) with alcohol insoluble solids (A.I.S., an accepted maturity measurement for many vegetables). Because the Shear Press is a simple mechanical test, it is a preferred field method compared with the more difficult and time consuming AIS measurement. However, data confirm previous findings that these maturity measurements do not correlate well with the percentage of pale green beans in the Fordhook lima bean samples. Since grade maturity is based on color rather than toughness or starchiness, Shear Press and AIS do not provide a good measurement of grade maturity. Field men concerned with these cooperative experiments consider the Shear Press valuable, however, because it provides an estimate of maturation rate in fields before any of the beans have turned from green to pale green in color.

Samples of dehydrofrozen peas were prepared in cooperation with the industry using the experimental belt-trough dryer. These peas will be used for evaluation in commercial-size test lots of canned soups, meat pies, and T.V. dinners, by a large food processing firm.

Retention of chlorophyll in processed green vegetables. The degradation of natural green color which occurs during the processing of green vegetables, particularly by canning, is a major problem in the industry. Cooperative work has been initiated with Brigham Young University to develop

improved and simplified methods for measuring the green pigment, chlorophyll, and its degradation product, pheophytin, in processed vegetables. At the same time, investigations were undertaken to separate and chemically characterize the pigments in processed vegetables as a basis for understanding the nature and the causes of the color change. Processing studies will be conducted when satisfactory analytical methods have been developed.

Two pressure retorts for processing experiments have been designed and constructed. One will handle standard glass and tin containers, and it can later be modified to simulate some types of agitating cook. The other will make it possible to sterilize vegetables under conditions of high temperature and short time (HTST).

Chemical methods of inactivating vegetable enzymes. A search for methods for chemically inactivating enzymes in vegetables was carried out at the request of the Quartermaster Food and Container Institute for the Armed Forces and with its financial support. The objective of this work was to gain information that might be used in the development of improved dehydrated vegetables.

The laboratory method for inactivating enzymes in vegetables, developed earlier, was extended to pilot plant conditions. Chemical, physical, and organoleptic tests were carried out on dehydrated and rehydrated cabbage before and after storage in the dry state under nitrogen gas and with desiccant at 100° F. for six months. After storage, cabbage treated with the acid-ethanol-surfactant mixture and steam-blanching gave negative tests for catalase, acetylcetase, and phosphatase, but a positive test for peroxidase. Negative tests had been obtained for all four enzymes prior to storage.

All lots of dehydrated cabbage retained most of their ascorbic acid and initial color, regardless of blanch or treatment. The same cabbage analyzed after rehydration, however, had lost a large proportion of its ascorbic acid. The total loss of ascorbic acid in processing, treatment, storage, and rehydration was greatest in unblanching and in the acid-ethanol-surfactant treated cabbage. Color measurements showed major changes with treatment and minor changes with storage. The cabbage changed its color toward yellow on treatment with the acid-ethanol-surfactant mixture. The odor and flavor changes in storage were small.

In general, the analyses of hydrated cabbage showed great changes with original treatments, and only small changes in storage at 100° F. for six months under conditions of low oxygen and moisture. Considerable deterioration occurred in the rehydration step.

This study has been completed.

Vegetables not widely grown in the United States. Following the survey of a large number of vegetables not commercially processed in this country, reported last year, emphasis has been placed on two of the more promising vegetables, edible-pod peas and Chinese waterchestnuts.

A quantity of edible-pod peas was frozen by a method which preserved the original quality and resulted in good stability in preliminary tests. When held at 0° F. up to one year the product was found to have maintained good quality. The product was evaluated organoleptically for flavor, texture, and color. In addition, objective measurements of color, chlorophyll conversion, and ascorbic acid were made. These indicated that this vegetable is adapted to preservation by freezing. One commercial pack of a few thousand cases has been produced using our suggested procedure. Examination of samples procured from the distributor indicated that the quality was well preserved.

A major deterrent to commercial development of Chinese waterchestnuts lies in the lack of peeling equipment. A laboratory-scale mechanical peeler was designed, fabricated, and tested. Using this unit, it was possible to prepare sufficient material for a study on the freezing of blanched and unblanched samples. Preliminary evaluations on both imported and domestic corms were promising. With the successful operation of the laboratory model peeler some effort has been expended in the design of a commercial prototype operating on the same basic principles. Preliminary tests of various adaptations have been made.

Further laboratory work is not contemplated at present. However, because of commercial interest engendered by the study, contacts will be maintained and advice given, based on completed work.

Freeze drying. The rates of freeze drying by conventional heating are very slow. Use of pressures higher than commonly employed, followed by atmospheric bin drying as a finishing step, seems to offer the lowest costs at present.

A study of factors affecting the rates of freeze drying of food pieces has been completed. The work was limited to definition of the mechanism of drying to the point of disappearance of a continuous ice phase, using conventional heating.

Freeze drying rates were measured on carrot, apple, and beef pieces lying on a hot surface. Heat is transferred through the already dried shell of each piece into the remaining ice core. Water sublimates from the ice surface and the vapor diffuses through relatively unbranched capillaries to the piece surface. The drying rate during this period is limited by the poor heat conductivity of the dried shell. Increased total pressure improves drying rates by facilitating heat transfer within the piece, in the moisture range studied. The dried matrices of various foods are nearly alike in heat conductivity. Improving conditions of heat transfer to the surface of the piece was ineffective as a means of increasing drying rate since the major resistance is between the surface of the piece and the ice core. All rates measured were very slow.

These low rates of drying by conventional heating suggest that no widespread adoption of the method for cheaper commodities will occur until new heating techniques are available.

Quick-cooking dry bean product. The effects of treating dry beans with calcium-binding chemicals in order to reduce their cooking time is being investigated. Research carried out in Sweden has indicated that the time required to cook dry peas is related to the calcium, pectin, and phytin they contain. It is thought that the reaction of calcium and pectin toughens the peas so that they are slower to cook soft. Phytin, a naturally occurring calcium-binding agent, opposes the calcium-pectin reaction and shortens the cooking time. On the assumption that a similar mechanism is involved in dry beans, the latter were soaked in alkaline phosphate solutions, their skins removed, and the cotyledons dried. While no truly quick-cooking products have been produced, a substantial reduction in cooking time was achieved under some conditions, and this approach appears promising.

Canning southern peas. Work was continued at Weslaco, Texas, on improving uniformity of quality in canned southern peas, by separating the raw stock into maturity levels. With lots of peas of the Blackeye type (California Blackeye No. 5) from two June harvests and one December harvest in 1958, screen-sizing in a rotary rod-screen grader, followed by separation of the several sizes into peas that floated and peas that sank in 3 percent brine proved effective. Brine flotation alone, without prior size grading, was not effective for classification into maturity levels. The size grader aided in reducing trash and improved the attractiveness of the peas; but it did not concentrate a majority of insect-damaged peas into any one sieve size.

High temperature-short time canning of vegetables. Work on the preparation, refrigeration, and evaluation of canned peas, green beans, corn, asparagus, and tomato juice sterilized by high-temperature, short time (HTST) techniques were continued under contract at Rutgers University. In general, the initial quality of the HTST processed products was superior to that of the conventionally packed materials. Recent results indicate, however, that deterioration of the initial high HTST quality proceeds even at 25° F. Equipment improvements made in the latter part of the report period will be discussed in more detail after a more appropriate testing interval.

Plans: Work on the high temperature-short time processing of vegetables will be continued under contract for a minimum of one more processing season.

Work at Weslaco, Texas, on the separation of southern peas into maturity levels before processing is being continued to determine the screen sizes and brine concentrations for the varieties Purple Hull, Cream, and Crowder.

Work will be continued at WU on the development of tomato juice powder; on development of commercially acceptable dehydrofrozen vegetables, including selection of suitable raw material; on retention of chlorophyll in processed green vegetables; and on the development of a quick cooking dry bean product. Work has been concluded on chemical methods of inactivating vegetable enzymes, and on vegetables not widely grown in the United States. No work is anticipated on freeze drying during the next year.

Publications: Factors Affecting Storage Stability of Spray-Dried Tomato Powder. J. C. Miers, F. F. Wong, J. G. Harris, and W. C. Dietrich. Food Technol. XII, 542. 1958.

Foam-Mat Drying. A. I. Morgan, L. F. Ginnette, J. M. Randall, and R. P. Graham. Abstract of Presentation to Institute of Food Technologists. Philadelphia, Pa., May 1959.

Sponge Drying. A. I. Morgan and L. F. Ginnette. Food Technol. XIII. Abstracts. Page 16. 1959.

Water-vapour Transfer in the In-package Desiccation of Dehydrated Foods. C. E. Hendel, R. R. Legault, W. F. Talburt, H. K. Burr, and C. R. Wilke. Reprinted from Fundamental Aspects of the Dehydration of Foodstuffs, 89-100. 1958.

Dehydrofreezing of Fruits and Vegetables. E. Lowe, and W. F. Talburt. Chap. 20 of Vol. 1, No. 1 of 1959 Ed. of the Americ. Soc. of Refrig. Engineers Data Book - Refrigeration Applications.

Evaluation of Yield and Quality in Relation to Harvest Time of Lima Beans Grown for Processing in Utah. D. K. Salunke, L. H. Pollard, E. B. Wilcox, and H. K. Burr. Bul. 407, Utah State Agric. Exp. Sta. 1959.

Determination of Sorbic Acid and its Disappearance from Pickle Brines. G. Alderton and J. C. Lewis. Food Research, 23 (4) 338-344. 1958.

New Processed Vegetables May Diversify Agriculture and Diet. A. D. Shepherd and H. J. Neumann. Chemurgic Digest XVII, No. 11, 3. 1958.

Freeze Drying Rates. L. F. Ginnette, R. P. Graham, and A. I. Morgan, Jr. Transactions of American Vacuum Society, 5:268. 1958.

6. IMPROVED CUCUMBER PROCESSING

SU

Problem: Increase the utilization of cucumbers, through reduction of losses and improvement of quality in cucumber fermentation, and development of new or improved pickle products.

Program: A continuing long-term program involving basic and applied microbiological and chemical studies; carried out in SU's Food Fermentation Laboratory, Raleigh, North Carolina, and in commercial plants in the South, East, and Great Lakes area, in cooperation with the North Carolina and Michigan Agricultural Experiment Stations, the National Pickle Packers Association, and the pickle industry; and involving about two Federal professional man-years annually.

Progress: Pectinolytic and cellulolytic enzyme inhibitor(s) from grape and other plant leaves. In 1957 it was reported that an extract from grape leaves would prevent the enzymatic softening of cucumbers during brine curing.

Since then, in cooperation with N. C. Agricultural Experiment Station scientists, considerable effort has been expended in an endeavor to isolate and identify the inhibitor substance(s) in the grape leaf which prevented the enzymic softening action. Although additional information was gained, the identity of the substance was not established. A chemical compound or combination able to prevent enzyme action would be of considerable economic value to the cucumber fermentation industry if it could be produced cheaply. Plant leaf sources other than grape are being investigated and some of these do contain inhibitor substances.

Cause and control of pickle relish spoilage. A number of yeast isolates from sweet pickle relish were classified as being close to the species *Trichosporon behrendii*, Lodder et Dreger van Rij. These cultures were isolated from spoiled relish shipped in fiber drum containers from two pickle manufacturers in two different areas of the country and had caused considerable economic loss. The organisms apparently developed in the top area of the relish, which was exposed to a small amount of headspace resulting from the type of construction used for this container. This space above the relish provided the necessary air for the rapid development of these yeasts, which are chiefly oxidative in nature and produce a highly aromatic aroma in the product, characteristic of ethyl acetate. The isolates studied were obtained from relish containing approximately 3 percent acetic acid, 28 percent sugar, and 2.3 percent salt. Fermentative species of yeasts associated with spoilage of pickle products are not able to grow in products with the above levels of acid, sugar, and salt.

Most of the *Trichosporon* isolates obtained by taxonomists to date have been associated with exudates of trees and wood products. One of the pickle companies concerned in the spoilage problem stored their fiber drums in an old furniture factory; this may have been responsible for the initial contamination. Also, the materials used in making the drums may contribute to the inoculum.

Control of bloater formation in cucumber brining. BLOATER (hollow cucumber) spoilage attributed to gaseous fermentation has been effectively controlled by use of sorbic acid in experimental cucumber fermentations; but more extensive studies are being undertaken to establish the value of sorbic acid under commercial conditions. These studies are being conducted in cooperation with the N. C. Agricultural Experiment Station and Mount Olive Pickle Company, Inc., Mt. Olive, N. C. Experiments conducted during the 1958 season involved testing the effectiveness of .02 percent sorbic acid in 25° Salometer (6.6 percent salt) brine. The data have not been evaluated to date. It has been noted during the course of the work, however, that sorbic acid disappears more rapidly in low salt than in high salt brines and its disappearance had a very noticeable effect on the internal cucumber structure.

Pickle spoilage potential of mold filtrates and other agents. Further studies on the 10 principal fungal species isolated from cucumbers (Applied Microbiology 6 (6): 427-440, 1958) have shown them to be a potent source of softening enzymes when grown under laboratory conditions. The type of

culture and medium used to obtain the growth filtrates was demonstrated to be an important factor in the pectinolytic activity and resultant softening action obtained. Under certain conditions a butyric fermentation and accompanying softening spoilage has been observed in experimental packs of pasteurized pickles.

Plans: Work on inhibitors of softening enzyme activity will be continued and expanded. Observations to date on plant sources of the inhibitors other than grape leaves need to be checked and more quantitative data obtained in cooperation with the N. C. Agricultural Experiment Station. Cooperation has been initiated with the Eastern Utilization Research and Development Division in isolation, identification, and characterization of the inhibitor(s) in grape leaves. Under a three-way Memorandum of Understanding between the National Pickle Packers Association, the N. C. Agricultural Experiment Station, and the USDA, work is being initiated to determine the effectiveness of irradiation of cucumbers in reducing microbial populations. Work on bloater control, fresh-pack dill pickles, and butyric acid fermentation spoilage is being continued.

Publications: Populations and Softening Enzyme Activity of Filamentous Fungi on Flowers, Ovaries, and Fruit of Pickling Cucumbers. J. L. Etchells, T. A. Bell, R. J. Monroe, P. M. Masley, and A. L. Demein. Applied Microbiology 6 (6): 427-40. 1958.

Influence of Sorbic Acid on the Growth of Certain Species of Bacteria, Yeasts and Filamentous Fungi. T. A. Bell, J. L. Etchells, and A. F. Borg. Jour. Bacteriology 77 (5): 573-80. 1959.

7. SUITABILITY OF VEGETABLE VARIETIES FOR PROCESSING

WU, SU

Problem: The quality of some processed vegetables is not uniformly high because varieties are often selected on the basis of agronomic characteristics with insufficient heed paid to processing characteristics. The proportion of vegetables marketed in processed form is constantly increasing and, therefore, it is important to consider processing as well as agronomic factors in their selection.

Program: A continuing long-term program of applied research on the suitability of new and established varieties of vegetables for processing is carried on at Prosser and Puyallup, Washington, in cooperation with the Washington Agricultural Experiment Stations and at Weslaco, Texas, in cooperation with the Texas Agricultural Experiment Station and vegetable growing and processing industries of the Lower Rio Grande Valley. This work involves about two professional Federal man-years per year.

Progress: Vegetables tested in Washington State. Studies on the suitability for processing of new varieties of sweet corn, green and wax beans, broccoli, and peas were made at the Puyallup laboratory.

The Golden Lake wax bean continued to show promise as a variety for canning. This and a number of new commercial releases were processed for demonstration to growers' and canners' groups during the year.

Sixteen freezing pea varieties grown at Mount Vernon were processed in the Puyallup laboratory. These varieties were exhibited at meetings of the Western Washington Horticulture Association and the Northwest Canners and Freezers Association and served to acquaint field men and processors with some of the recently released pea varieties.

Studies were made of 13 varieties of sweet corn, each of which was harvested at several different stages of maturity. Soluble solids, moisture, and penetrometer readings were taken at each harvest maturity. The tenderness ranking by taste panel placed the samples in the same order as the penetrometer readings. As in 1957, the refractometer readings percent moisture content relationship was a straight line function when the data were analyzed statistically, and the slope was the same for all thirteen varieties tested. The regression lines for the two seasons' results were parallel, with the 1958 line being slightly lower.

Twelve varieties or strains of broccoli were evaluated for color, size of head, and side shoot. Of those varieties adaptable to the area, Northwest Waltham appeared best for freezing. The Chinook variety, a recent Western Washington Experiment Station introduction, was good, but not outstanding because of an occasional yellow flowerlet.

Some investigations were undertaken to determine how to preserve the color of canned hothouse rhubarb. When freshly packed, the product has a very bright, appetizing, pink color which fades rapidly when stored at or above 60° F. The most satisfactory method proved to be holding the product at 35-40° F., although addition of small amounts of blueberry juice also produced a product which was attractive and did not lose its color so fast.

Vegetables tested in Texas. Work was continued at SU, in cooperation with Substation 15, Texas Agricultural Experiment Station, Weslaco, to aid in selection of new varieties and strains of southern peas of improved suitability for processing. Of four varieties and 11 strains of peas canned and evaluated, California Blackeye No. 5 was the highest producer of green pod peas and had the highest percentage shellout for the Blackeye-Purple Hull group. Cream 7 was the highest producer and Cream 20 had the highest shellout for the Cream group.

In the canned packs the percentage of split peas was higher for the Cream group (Cream 9 highest with 54.9 percent) than for the Blackeye-Purple Hull group (California Blackeye No. 5 highest with 47.7 percent). The percentage of defective peas was very low for all varieties and strains. The color of Purple Hull 49 was the most desirable for the Blackeye-Purple Hull group and Extra Early Blackeye the poorest. Cream 16, 20, 10, and 40 strains maintained the most desirable bright color of the cream group the color of

Cream 7 and Cream 9 was slightly gray. In general, the variety Purple Hull 49 and the strain Purple Hull 13 were the most desirable for the Blackeye-Purple Hull group and Cream 16 was the most desirable for the Cream group.

In further cooperative work, seven varieties and five breeding lines of bush green beans harvested on three dates in May 1958 were size graded, representative samples canned, and the packs evaluated, after nine months' storage at room temperature, for percentage of seed in pods, crude fiber, and color (Hunter meter). In addition sensory evaluations were made for color, stringiness, and texture.

In this test, Earligreen was the highest yielder and had a very small percentage of large beans, but the color was the lightest of any, the crude fiber tended to be high, and shriveling of the pods occurred during canning. Topmost was second in yield, but had the highest percentage of large beans, a tendency of this variety. The color was good and the fiber low. Pearlgreen ranked third in yield. While the percentage of large beans was higher than that of some of the other varieties, it was about half that of either Topcrop or Topmost. The color was good, but the fiber was high. Breeding line B-3095-3 was fourth in yield, the proportion of large beans low, and the pod color good; but the crude fiber of sives size 5 beans for 2 harvests was too high for USDA grade. Topcrop was among the high yielders, but produced a very large percentage of oversize beans; and the seeds developed rapidly, resulting in rough appearing pods for the larger beans. The crude fiber was surprisingly low. Breeding line Corneli 141, although not the highest yielder, could be considered one of the better beans in the test, with pods very low in over-size, and long, straight and smooth. In considering any of these beans for breeding lines, close attention should be given to date of maturity. Pearlgreen, Runnerless Ranger, Topmost, and Topcrop are early; Corneli 14, Earligreen, Tenderwhite, B-3095-3, and B-3034-1-2 are midseason; and Northrup King 104 and 103, and Hyscore are late.

In other tests sensory panel evaluation of beans canned from a row-spacing experiment revealed no consistent differences attributable to the differences in spacing. While closer spacing substantially increased the acre-yield of raw beans, no appreciable differences in pod characteristics were observed. Evaluation of the canning quality of four varieties of beans grown by a commercial packer indicated that Pearlgreen was the most desirable. While the pods were a little large, they were well-filled and had a low content of seed and fiber.

Work in cooperation with the Texas Agricultural Experiment Station and Rio Farms, Inc., included (a) the evaluation, for canned juice manufacture, of 26 breeding lines and four varieties of tomatoes; and (b) the canned whole-pack products of two varieties and two breeding lines processed on three different dates during the season.

In the former tests all of the breeding lines grown at Texas Substation 15, with the exception of W-11-13, made a "fancy" juice. The yields of raw stock for all the breeding lines would be considered good for the Rio Grande Valley.. Strains W-275 and W-21-3 appeared to be the most desirable canning

types, although the total yields were slightly lower than those of some of the others. The fruit of these two lines crack very little, as compared with some of the other lines, when left on the vines until red ripe.

In the second series of tests, the drained weight percentages of the two varieties, Homestead and Rutgers, were higher than those of the two breeding lines, W-11 and W-275, and for the latter the drained weights of commercially canned samples were lower than those of the corresponding laboratory-canned samples. This was due to differences in handling, but the differences in drained weights were not as great as expected. Addition to each can of a 30-grain salt tablet containing 20 percent calcium chloride increased the percentages of tomatoes retained on the draining screen from two percent to 17 percent depending upon variety and date of harvest. The calcium also increased the percentage of whole tomatoes as much as 18 percent to 46 percent, depending upon variety or breeding line. Tomatoes canned June 3 and 6 had a more desirable red color than did those canned June 12. The Homestead variety had the best red color for the first harvest, but by June 12 it had the poorest color.

All of the two varieties and two breeding lines of tomatoes would be classed as fair canning types for this area. One variety or line could hardly be called far superior to the others. Rutgers would be graded low because of poor color throughout the season. Homestead changed in color and the pack without salt was given the lowest flavor score. The canned samples of both the W-11 and W-275 lines were slightly soft; but this condition could be considerably improved by adding calcium salt.

Plans: Cooperative effort in evaluation of Southern peas, green beans, and tomatoes for processing characteristics will continue indefinitely as new varieties and strains are developed and put under test. Cooperative work with the Washington Agricultural Experiment Station will continue at the present level.

Publications: Variety and Strain Evaluation of Southern Peas. T. S. Stephens and R. T. Correa. J. Rio Grande Valley Hort. Soc. 13: 129-34. 1959.

8. CONTROL OF SPORE-FORMING BACTERIA

WU

Problem: The heat required to inactivate spores of food spoilage bacteria has a deleterious effect on the quality of canned vegetables. This quality could be greatly improved if the heating requirements could be materially reduced.

Program: A continuing long-term program of basic and applied research on the heat resistance of bacterial spores as it relates to the canning of vegetables is being conducted, involving three professional Federal man-years per year. Cooperative research is under way at the University of Illinois on compositional changes in bacterial spores upon severe handling.

Progress: The attack on this problem has involved two approaches: the empirical screening for substances that might reduce the heat-resistance, and studies of the fundamental nature of the heat-resistance of bacterial spores.

The empirical search has led to a number of chemicals that give moderate decreases in the heat resistance of spores of representative food spoilage bacteria. Commercial application of two of these, the antibiotics subtilin and nisin, awaits only further toxicity testing and Food and Drug Administration clearance. Preliminary work indicates that both are nontoxic.

The sensitivity of severely-heated spores of the spoilage organism *Bacillus coagulans* to various nutritional and environmental factors has been demonstrated. Work is underway to determine the density of spores and state of binding of water in spores of this organism and of *B. megaterium*. Conditions have been achieved for good production of spores. The kinetics and nature of the changes that occur in spores of *B. coagulans* on lethal heating are being investigated cooperatively at the University of Illinois.

Inability to obtain good crops of spores of certain of the more heat-resistant spoilage organisms hinders investigations on control of these organisms. A study of the sporulation requirements is underway. Particular attention is also being paid to the necessity for removing traces of enzymes and structures of the parent vegetative cells from the spore crop.

An unexpected by-product of the work on spores has been the development of a biological field test for quaternary ammonium compounds and related germicides. Such germicides are commonly used in restaurants as a dishwashing rinse, in dairies, in washing of eggs, etc. Analysis of these drugs has always been a problem due to: lack of a general method effective for all quaternary ammonium compounds; complexity; and difficulties of interpretation due to an absence of clear-cut results. Spores may provide an ideal test system for such drugs: they are highly stable in the dry state; they germinate with phenomenal rapidity in the presence of specific nutrients (e.g., l-alanine); and the germinating spore is uncommonly susceptible to drugs, making it a sensitive system. The test has not been tried under field conditions.

Plans: Work on sporulation requirements, the physical state of water in spores, and factors inhibitive of severely-heated *Bacillus coagulans* will be continued at the present level.

Publications: Search for Substances which Reduce the Thermal Resistance of Bacterial Spores. H. David Michener, P. A. Thompson, and J. C. Lewis. Appl. Microbiol. 7, 166-173. 1959.

Isolation of Subtilin A. G. Alderton and N. Snell. J. of Amer. Chem. Soc. 81 (3) 701. 1959.

Influence of pH on the Antibacterial Action of Subtilin A. L. E. Sacks and J. W. Pence. J. of Gen. Microbiol. 19 (3) 542-550. 1958.

Effect of Subtilin and Nisin on the Spores of *Bacillus Coagulans*. L. Leon Campbell, Jr., and E. E. Sniff. J. Bacteriology 77, 766. 1959.

9. DISPOSAL OF LIQUID EFFLUENTS FROM PROCESSING PLANTS

EU

Problem: Develop information on the best methods for disposing of liquid effluents from fruit and vegetable processing plants in the eastern region.

Program: A contract with Manhattan College, New York, N. Y., involving a total expense of \$22,668 and carried out in cooperation with the National Cannery Association, the New York Cannery and Freezers Association, the Tri-State Packers Association, the Pennsylvania Cannery Association, and 19 processing plants in the six-state area comprising New York, New Jersey, Delaware, Maryland, Virginia, and Pennsylvania; studies initiated in 1956 and completed in 1957 were concerned with both field work and laboratory investigations.

Progress: Technical work on this project was completed and the contract was terminated upon approval of the final report. This report was in the form of a manual providing information for the benefit of processors who have had little or no experience in waste disposal. Copies of this manual are being supplied to all interested parties.

Plans: This project has been completed and no further work along these lines is anticipated.

Publications: Study of Fruit and Vegetable Processing Waste Disposal Methods in the Eastern Region. W. W. Eckenfelder, Jr., Charles Woodward, John P. Lawler, and Robert J. Spinna. Manhattan College, New York, N. Y., Sept. 1958.

III. HOME ECONOMICS RESEARCH

1. MINERALS IN VEGETABLES

HN

Problem: More accurate and up-to-date information is needed on mineral elements in vegetables as produced and marketed today for determining the relative importance of vegetables in diets.

Program: A continuing long-range program at Beltsville, Maryland, of laboratory analyses to obtain comprehensive data on the mineral content of common vegetables from representative producing areas of the U. S. Informal cooperation with growers and wholesalers is maintained as necessary to obtain pertinent information on origin of samples. Approximately two professional Federal man-years per year are devoted to this work.

Progress: Four additional leafy green vegetables considered important in the American diet have been collected in duplicate from two major producing areas since July 1958. Analysis of these vegetables for 10 mineral elements has not been completed. The four vegetables include Chinese cabbage, collards, curly endive, and escarole. A report entitled "Mineral Elements in Fresh Vegetables from Different Geographic Areas," was published. A semi-popular article describing the findings of two years' work on nine different vegetables ranking high on the consumption list is scheduled to appear in the December 1959 issue of the magazine "Agricultural Research."

Plans: Limited work is being planned for the determination of mineral elements in other vegetables.

Publication: Mineral Elements in Fresh Vegetables from Different Geographical Areas. Homer Hopkins and Jacob Eisen. Agricul. Food Chem. No. 9: 633-638, Sept. 1959.

2. QUALITY AND VITAMIN CONTENT OF VEGETABLES AS PURCHASED AND AS EATEN HN

Problem: A problem of homemakers or food managers in restaurants and institutions is to learn how to select and make the best use of the vegetables available in improving the diet and eating habits of people. In order to do this, information is needed on the nutritive values in the different kinds and forms of vegetables available, how to preserve their valuable qualities before and during cooking, and how to prepare and serve them so as to be attractive and acceptable.

Program: This work is a continuing long-term basic laboratory program at Beltsville, Maryland, to ascertain the nutritive value and edible quality of selected vegetables as commonly prepared for the table. Vegetables selected for study are those now important in diets, or potentially important as sources of needed nutrients, and those most affected by nutrient losses and quality changes during cooking. Knowledge of the relation

between the physico-chemical changes that take place during cooking and the eating quality is sought to aid in the selection of cooking procedures for optimum quality under varying circumstances. Part of this research is cooperative with the Agricultural Marketing Service. Four to five professional Federal man-years are involved annually.

Progress: Significant losses of ascorbic acid were found to occur during cooking of fresh broccoli by boiling, steaming, and pressure cooking. The losses were due chiefly to leaching of ascorbic acid into the cooking liquid. Under the best of conditions tested, 60 to 85 percent of the original ascorbic acid content was retained in the cooked broccoli. This was when one pound trimmed fresh broccoli was (1) boiled in 300 gm water in a covered pan for 10 minutes, (2) steamed for 10 minutes, or (3) cooked in a pressure saucepan at 15 pounds pressure for two minutes. Overcooking for even five minutes resulted in about 10 percent more vitamin C loss. Starting the cooking of broccoli in boiling water or in cold water made little difference in ascorbic acid retention when a small amount of water was used. Cooking in large amounts of water caused excessive leaching of ascorbic acid into the water within the first five minutes of cooking. The addition of one gram sodium bicarbonate to the distilled water used for cooking appeared to have little affect on ascorbic acid retention.

Ascorbic acid was found to be uniformly distributed throughout the stem of fresh broccoli. Stems less than one-half inch in diameter contained a greater percentage of ascorbic acid than did those of large diameter. No relation was found between size of broccoli head and percentage content of ascorbic acid. Some of the fresh broccoli contained considerable amounts of dehydroascorbic acid and diketogulonic acid.

Carotene was concentrated chiefly in the green outer portion of the stems. Smaller, less mature heads contained a lower percentage of carotene than did the larger ones. There were no significant losses in carotene in the cooking of broccoli.

The color of fresh broccoli deteriorated significantly when cooked for increasing length of time by any of the procedures. Texture improved with cooking up to about 10 minutes by most of the methods under atmospheric pressure but was impaired by 15 minutes or more cooking. At 15 pounds pressure, two minutes cooking was sufficient for good texture. In general the flavor was best developed when the texture was nearest optimum.

Frozen broccoli obtained directly from the processor contained less dehydroascorbic acid than did fresh broccoli. When stored for 36 weeks at 0° F. the frozen broccoli showed only slight decreases in reduced ascorbic acid content and slight increases in dehydroascorbic acid and diketogulonic acid. There was no apparent decrease in carotene content in the storage interval between 17 and 61 weeks at 0° f. The actual amount of vitamin C present in cooked frozen broccoli depended on the amount contained in the vegetable before cooking. Frozen broccoli lost more ascorbic acid in the first five minutes of cooking than did fresh broccoli but the

percentage retention of ascorbic acid in either fresh or frozen when cooked to optimum tenderness was about the same. Frozen broccoli from two 10-ounce packages was cooked satisfactorily by boiling in one cup water in a covered pan for 10 minutes, steaming for 10 minutes, or cooking at 15 pounds pressure for two minutes.

Research is in progress on six vegetables high in national consumption -- brussels sprouts, lima beans, green snap beans, peas, spinach, as well as broccoli -- frozen samples are being obtained seasonally from the local retail markets and from four different areas of the United States. Canned and fresh samples are being obtained from the local market. Chemical analyses for vitamin C and carotene and quality analyses for color, flavor, texture, and yield of cooked product have been made on the six frozen vegetables in three seasons (winter, spring, and summer) and two locations (Philadelphia and New Orleans). Yield and quality evaluations also have been made on two replications of four different brands of each of four canned vegetables (green beans, green peas, spinach, and lima beans). Work has been completed on three fresh vegetables (spinach, green peas, and green beans) purchased at the local market.

Plans: Laboratory work on fresh, frozen, and canned vegetables will be completed and a report of this research will be prepared. The results will be reviewed to determine which direction the work should take, if extension seems justifiable within the funds available.

Pu l i c a t i o n s:

The determination of Chlorophyll and Pheophytin in Broccoli Heated by Various Procedures. James P. Sweeney and Margaret Martin. Food Research 23 (6): 635-647. 1958.

Effect of Cooking Methods on Broccoli. I. Ascorbic Acid and Carotene. J. P. Sweeney, G. L. Gilpin, M. G. Staley, and M. E. Martin. Jour. Amer. Dietet. Assoc. 35 (4): 354-358. 1959.

Effect of Cooking Methods on Broccoli. II. Palatability. G. L. Gilpin, J. P. Sweeney, V. J. Chapman, and J. N. Eisen. Jour. Amer. Dietet. Assoc. 35 (4): 359-363. 1959.

Factors Affecting the Ascorbic Acid and Carotene Content of Frozen Broccoli. M. E. Martin, J. P. Sweeney, V. J. Chapman, and G. L. Gilpin. Paper presented at the 19th An. Mtg. of Instit. of Food Technologists, Phila. Pa., May 1959. (Abs. in Food Technology 13 (4): 33-34, April 1959).

3. AGRICULTURAL CHEMICALS AND FOOD FLAVOR

HN, ENT, CR

Problem: To assure that agricultural and food processing chemicals caused no undesirable changes in flavor or other consumer qualities of foods which might interfere with their acceptance, palatability as well as wholesomeness must be ascertained in the developmental stages before the chemicals are marketed for use.

Program: HN maintains at Beltsville a continuing program cooperative with Divisions of Farm Research to investigate the effect of use of agricultural chemicals on flavor of commodities as prepared for eating. As sample size and variety permit, the Division also makes studies to improve methods for conducting of palatability evaluation. About two professional man-years annually are involved in HN.

Progress: The flavor of foods exposed to certain agricultural chemicals in their production has been investigated in continued cooperation among HN, CR, ENT, and with the Northeastern Regional Research Project, NE-15.

Carrots of the Germain's #48, Improved Long Type variety were grown at the California field station of ENT in plots treated with chlordane at dosage rates of 5, 10, or 20 pounds per acre or heptachlor at the rates of 3 or 6 pounds per acre and in untreated plots. No significant differences were found in mean scores for flavor of raw carrots. Cooked carrots prepared from samples grown in any of the treated soils received significantly higher mean flavor scores than samples grown in untreated soil. These results which indicate that treatment of soil in the above amounts had no adverse effect on the flavor of carrots grown in that soil are in agreement with those reported in 1958 on carrots grown in Maryland.

Sweet corn of four varieties -- Aristogold Bantam Evergreen, Seneca LV 7, NI 199, and Iochief-- grown on untreated plots and on plots treated with simazin at the rate of 4 pounds per acre, were evaluated for off-flavor in the canned product. Panel mean scores indicated that the use of simazin at the rate of 4 pounds per acre produced no detectable off-flavor in these varieties of canned sweet corn. Previous flavor tests (reported last year) on one variety -- Aristogold Bantam Evergreen -- gave the same results.

Plans: Cooperative testing for palatability and methodological studies of flavor evaluation will be continued as opportunity permits.

4. HOUSEHOLD PRACTICES IN HANDLING AND STORAGE OF FROZEN FOODS HHE

Problem: Household practices in handling and storage of commercially frozen foods including vegetables from the time of purchase at retail outlets until prepared for use in the household affect the quality to the consumer of such foods, yet little information on such practices is available.

Program: Surveys are being made to obtain information from representative samples of households on their practices in the handling and storage of commercially frozen foods to provide data useful in helping families improve their food management practices. A contract has been let with Alderson Associates, Inc., Philadelphia, Pennsylvania, to collect the above indicated information. Less than one professional Federal man-year is involved annually.

Progress: Two seasonal surveys of 300 representative housekeepers in Baltimore, Maryland, are being conducted under contract. Information obtained from the households includes a description of available freezing facilities and a temperature reading of compartments in which any frozen food products are being stored; handling practices (i.e., time between removal from store freezer compartment to home refrigeration or use, and whether insulating materials are used) with respect to commercially frozen vegetables, fruits, and juices purchased during the seven days preceding the interview; and length of time held in storage of such of these three types of foods as were used during the same period.

The first of the two surveys, following a pretest of the questionnaire was carried out in September 1959. In January the same households are to be visited in order to determine handling practices under different seasonal temperature conditions.

Plans: The data from Baltimore will be analyzed. It is hoped that coverage will be extended in 1960 to another city and to such other commercially frozen foods as baked goods and meat and poultry.

III. MARKETING RESEARCH

A. Market Potentials, Preferences, and Development

1. NEW AND IMPROVED MERCHANDISING METHODS

MD

Problem: A continuing need exists to encourage improvements in the retail merchandising of vegetables to maintain a strong competitive position for such products in the market place.

Program: A continuing long-term program of marketing research involving field studies and analyses of merchandising methods on a national, regional, or local basis depending on the requirements of the problems being considered. In many instances work is undertaken in cooperation with food stores as well as agricultural groups. Less than one professional Federal man-year annually is required.

Progress: A market test of a new variety of cantaloup was conducted to determine the feasibility of expanding from experimental fields into commercial production. Prices for the new variety were higher than for other Texas cantaloups, but lower than for those from Arizona and California. Wholesalers reported that the cantaloups were of good quality and nine out of ten housewives indicated that they would buy this variety again.

Plans: It is anticipated that a research study will be conducted of the relative effectiveness of various methods of displaying high quality winter tomatoes harvested at the pink rather than mature green stage. The Market Quality Research Division will cooperate by evaluating the quality change of the tomatoes under different methods of display.

Publications: A Market Test for a New Variety of Cantaloup. Hugh M. Smith. USDA Agricultural Marketing, June 1959.

B. Measurement and Evaluation of Market Quality

2. MEASUREMENT OF MARKET QUALITY FACTORS

MQ

Problem: New and improved methods and techniques of identifying and measuring quality factors in vegetables are needed to provide better inspection, grading, and standardization of these commodities.

Program: This continuing program of applied and basic research is conducted at Beltsville, Maryland, and at College Park, Maryland, in cooperation with the Maryland Agricultural Experiment Station and involves about three professional Federal man-years annually.

Progress: Color and Condition of Tomatoes for Manufacture of Strained Tomato Products. A new raw tomato juice colorimeter was developed which measures and computes the color of raw juice according to a formula that gives good agreement with color scorings made by Inspectors. The formula combines tri-stimulus color readings into a single value having an effective range from 40 to 100, with increasing values indicating better color. The new instrument was used in a retest of the color formula and this was found to correlate with Inspectors' scorings of raw juice to the extent of 0.96, thus substantiating the findings of the previous year's research.

This procedure evaluates the color and condition of tomatoes being sold by farmers, and arrives at the color score and the percent usable weight of tomatoes in the loads. The color score is determined from a sample of raw juice by use of the new colorimeter. The percent usable weight is determined by a subjective evaluation of the condition of the tomatoes in respect to defects and diseases, and excludes color. In this evaluation, four separations are made: (1) Tomatoes requiring 0 to 5% trim (substantially sound and disease-free tomatoes); (2) tomatoes with defects requiring 6 to 20% trim; (3) tomatoes with certain diseases and molds, affecting up to 20% of the fruit tissue; (4) culls (requiring more than 20% trim due to either diseases or defects). The calculation of percent usable weight gives full credit for the weight of tomatoes in category (1), the trimmed tomatoes of category (2), and 80% of the weight in category (3). No credit is given for the fourth category (culls). These two factors, color score and percent usable weight are expected to provide information sufficient for the pricing of farmers' loads of tomatoes.

A new inspection table was designed to be used in the new procedure and permits the grading of a fraction of the contents of individual hampers, with consequent inclusion of more hampers in the sample and prediction of the quality of the loads with greater accuracy.

This new modified procedure was demonstrated to farmers and canners in New Jersey, Pennsylvania, Ohio, Indiana, and New York during the 1959 harvest season.

Texture of Asparagus. Data on the shear resistances (toughness) of individual stalks of asparagus were compared with the shear resistance of bulk sample duplicates. It was found as the shear resistance of a bulk sample increased up to approximately 160 pounds force, variability among individual stalks of its duplicate sample increased. Beyond approximately 160 pounds, a slight decrease in variability was noted. The bulk sample reading, in addition to providing this information concerning variability among stalks, can also be used to indicate the approximate percentage of stalks with an unacceptable degree of toughness. This prediction appears sufficiently good to be useful in quality control in canning and freezing plants, but is not considered sufficiently precise for use in grading asparagus prior to purchase. The latter will require instrumentation which will take readings rapidly on the individual stalk basis.

Quality Evaluation of Sweetpotato Breeding Lines: Twenty-three selections were evaluated for flavor and appearance. Five selections were from the Beltsville breeding program and the remainder from experiment stations cooperating in the Southeastern States regional test program. Both vacuum and syrup packs were evaluated. Porto Rico I and Jersey Orange were used as standards for comparison of the new material.

Selections B-6716, Okla 65, L-1-80, NC-162, HM-204 and the established variety Sunnyside ranked well in comparison to the above variety standards.

Action taken by the Southeastern regional committee on the basis of these and other data from cooperating experiment stations were to continue L-1-80, L-3-77, and NC-171 in the replicated tests of the group; advance B-6652, HM 288 and M-97-4 from observational to replicated test and to retain L-3-64 and L-4-89 in observational trial. Nine other selections from a number of stations were dropped from the regional trials. These decisions were based on horticultural characteristics in addition to canning quality.

Plans: Attention will be given to research on instrumentation for color evaluation of processed tomato juice. Work on development of objective measurement of quality in processed Southern peas will be carried on, in cooperation with Maryland Agricultural Experiment Station. Evaluation of the market quality of sweetpotato breeding lines will continue at about the present level.

Publications: The Effect of Variety on the Quality of Frozen Green Soybeans. K. D. Demaree. Soybean Digest, 19 (10): 16-18. August 1959.

A Study of Some of the Factors Affecting the Grade and Relationships of Fresh and Processed Vegetables. IV. Whole Kernel Sweet Corn for Canning and Freezing. Ohio Agr. Exp. Sta. Bul. No. 826. Jan. 1959

C. Product Protection During Marketing

3. POST-HARVEST PHYSIOLOGY AND STORAGE

MQ

Problem: Marketers of vegetables sustain losses from chilling injury, wilting, aging and color changes. Basic research is needed to determine causes and develop controls for these disorders.

Program: A long-range program, with emphasis on physiological studies or environmental response. The work, conducted at Beltsville, Maryland, and at field laboratories in Fresno, California, Harlingen, Texas, and East Lansing, Michigan, involves about 4 professional Federal man-years annually.

Progress: Storage of Vegetables for Navy Supply. Semi-commercial scale tests were conducted from the four major western lettuce producing areas, comparing conventional methods of packaging with the new methods developed by the Department. The best method was to trim the heads in the field and place each in a polyethylene bag before placement in the

carton or crate. Lettuce packed this way showed less weight loss, less decay and remained greener and crisper than that in the conventional pack. For example, in lettuce from the Imperial Valley, total losses in lettuce packed in individual polyethylene bags during seven weeks of storage at 33° F. was 12 percent, while in the conventional navy pack, with each head lined in parchment wraps, the loss was 24 percent. Unwrapped heads had 28 percent loss. The Navy Department has taken steps to adopt this improved packaging procedure.

Russet spotting was observed to be considerably worse in lettuce stored at 38° F. than in lettuce stored at 33°, confirming previous tests. In one test, for example, russet spotting was observed on an average of one leaf per head of lettuce stored at 33°, but was observed on over 6 leaves per head stored at 38°. The type of storage package had no effect on the amount of russet spotting.

Artificial Defoliation of Beans. Defoliation research on pea beans was continued to determine the effect of defoliants on quality. Results from 1958 defoliated fields indicated a reduction in moisture comparable to the previous year's results. Defoliation again hastened maturity and improved cooking quality of beans as shown in the previous year's results. Weedy fields were more easily harvested after defoliation and less physical damage was evident in the threshed beans.

Beans from 1958 tests were tested both for germination and for seedling vigor. No significant difference was found between defoliated and check beans. Panel taste tests indicated that canned beans from the defoliated lots of both the 1957 and 1958 crops were detectably more tender than those from the non-defoliated lots. This information was verified by shear press data which measured the resistance of force of 56.7 pounds for defoliated and 87.5 for checks in the 1957 crop. For the 1958 crop these values were 62.7 and 91.2, respectively.

Provitamin A in Vegetables. Fresh leafy, green vegetables are a rich source of provitamin A (carotene), but under adverse temperature and humidity conditions it may be lost quite rapidly. Turnip greens, kale, collards, rape, and spinach were subjected to slow, moderate and rapid wilting conditions at 32°, 50° and 70° F. In general, loss of provitamin A was proportional to the degree of wilting and to the increase in storage temperature. Wilting was of much less importance than adverse temperature in hastening the losses. The loss per day at high humidity (all products and all temperatures) averaged 6.9 percent compared to 10.4 percent at low humidity--half again as fast at low humidity. The loss per day at 32° F. (all products and all humidities) averaged 1.7 percent compared to 18.1 percent at 70° or more than 10 times as fast at 70° as at 32°.

Tomatoes from Frozen Vines. Studies were continued at Beltsville, Maryland with fall-grown Rutgers tomatoes to determine whether mature-green tomatoes can be successfully ripened after the vines are frozen. In 1958 a killing frost did not occur until November 8. At that time the

temperature remained below 30° F. for 9 hours and dropped to a minimum of 22.5° remaining for 2 or 3 hours. All vines were completely killed and exposed fruits were visibly frozen. Naturally protected fruits were frozen only slightly or escaped entirely. About 12 percent of apparently sound mature-green tomatoes developed symptoms of freezing injury at 65° within 2 days after harvest. A total of 16 percent developed evidence of freezing injury during ripening and two thirds of these decayed. Sound fruits were of normal color when ripe. On November 11, the temperature was below 30° for about 4 hours and the minimum dropped to 25.5° for about one hour. Naturally sheltered fruits escaped visible damage, but had more hidden damage than tomatoes harvested after the first freeze. After 2 days at 65° about 27 percent showed freezing injury. By the end of the ripening period about 40 percent showed injury. The total decay was 38 percent and 21 percent was traceable to freezing injury. Sound fruits were abnormally soft.

Determining the ability of tomatoes to ripen after the vines have been frozen is a periodic problem in Florida. Data from these tests will aid the tomato industry with this problem.

Handling Eastern Tomatoes. Bruising injury is the most serious cause of loss in marketing fresh tomatoes. Studies were designed to determine: (1) The extent of damage from different pressure impacts; (2) symptoms of pressure-bruising injury as related to cause; and (3) the effect of stage of ripeness on symptoms of bruising injury.

About twice as much pressure was required to crush mature-green tomatoes as those that were one third ripe. Internal symptoms of bruising injury varied with stage of ripeness when injured, and with extent of injury. Internal injury could not necessarily be judged by external appearance. Internal symptoms of bruising injury observed were as follows: (1) Retention of green color in fruit wall and in jelly around seeds; (2) cloudy appearance of jelly in seed cavities; (3) failure of jelly to form, making the seed cavity dry; (4) various degrees of water soaking and the seeds detached from the placenta; and (5) advanced watery breakdown in which the contents spilled out from the locules when the fruits were cut.

Studies on bruising injury are important not only because of the extensive losses incurred, but also because the hidden nature of the damage makes it difficult to detect.

A report of studies on a phase of this project concerning proper temperature control has been widely distributed by the Florida Tomato Committee and by other organizations.

Chilling of Peppers and Squash. Previous tests have shown that chilling injury may occur, and that Alternaria rot is a reliable indication of serious chilling injury in both bell peppers and acorn squash. Inoculation tests to study the relation of chilling injury to Alternaria rot are underway. In preliminary tests peppers and squash held at 32° and 35° F. developed active

decay whereas those held at 45° or above developed only incipient decay following inoculation. In each commodity the ability of the fungus to penetrate unbroken skin depended on the extent of chilling injury. Information from this study can be used as a guide in the safe transport and storage of acorn squash and bell peppers.

Russet Spotting in Lettuce. Market inspection reports on commercial lettuce shipments and observations made on experimental lots suggest that the development of russet spotting during transit or storage may be increased when lettuce has been exposed at some time during the 4 to 6 weeks before harvest to air temperatures in the field that are 84° F. or higher. One day at high temperature appears to be sufficient to induce this defect. Macroscopic and microscopic examination showed that, (1) russet spots are randomly distributed on a given leaf; (2) the conducting elements may or may not be affected; (3) normal cells adjacent to affected cells are indistinguishable from normal cells not in the vicinity of russet spots; and (4) individual russet spots do not seem to enlarge once they have appeared.

Modified Atmospheres for Asparagus. The recent trend toward shipping asparagus in relatively airtight railroad cars and the possibility of packaging spears in film bags or liners at shipping point requires some determination of the effect of such atmospheres on the commodity during transit and marketing. Atmospheres tested in the laboratory ranged from 0% CO_2 and 21% O_2 (normal air) to 20% CO_2 and 1% O_2 . Asparagus spears were held in these atmospheres for one week at either 37.5° or 50° F. Injury was not found in asparagus exposed to atmospheres of 10% CO_2 or less combined with 10% O_2 or more when held at 37.5° F. Greater deviations from a normal atmosphere caused injury. Atmosphere modification, even within the safe range, tended to reduce the incidence of soft rot, the most common market disease of asparagus, and retarded toughening. These effects were still evident after holding the spears in a normal atmosphere at 59° for 2 days subsequent to the modified atmosphere storage at low temperature. At 50° F. the advantages of atmospheric modifications were outweighed by the danger of injury from excess CO_2 or low O_2 .

Respiration Determinations. Respiration rate measurements of Texas vegetables were continued with determinations on cabbage, romaine, leaf lettuce, and head lettuce. Of these four leafy vegetables, leaf lettuce had the highest rate of respiration and cabbage the lowest rate. By far the highest rate of any of the commodities thus far has been that of Clemson Spineless Ribbed okra. Calculations of the amount of heat produced (in b.t.u. per ton per 24 hours) were 98,000 at 88° ; 77,500 at 80° ; 57,500 at 70° ; 31,500 at 60° ; 20,000 at 50° ; and 12,000 at 40° F. There is increasing commercial interest in okra as a specialty crop and information regarding its refrigeration is needed.

Storage of Asparagus Roots. Dormant Mary Washington asparagus roots stored for 2 months at 30° , 32° , 36° , and 40° F. in unlined standard wire-bound crates had weight losses of 9.7, 7.3, 12.1, and 16.2 percent, respectively. Similar plants stored at these temperatures in perforated and nonperforated polyethylene-lined crates lost no weight. Upon removal

from storage, decay was found in all test packages but was more extensive on plants stored at higher temperatures and on those stored in film. Field survival ranged from a high of 85 percent for plants stored at 30° F. in either lined or unlined crates to a low of 60 percent for those stored at 40° F. in non-perforated film-lined crates.

Suberin Formation in Vegetables. A spectrophotometric and paper chromatographic study of the ethanolic extracts of wounded tissue of 8 vegetables was made after 0, 1, 2, 3, 4, and 8 days of healing (barrier formation). In each case phenolic and coumarin-type compounds accumulated in the wounded tissue during healing. Sweetpotatoes, Irish potatoes and eggplant showed an approximately 5-fold increase in chlorogenic acids while forming a barrier. Carrots and beets accumulated chlorogenic acids in smaller amounts along with several unknown fluorescent compounds. Parsnips accumulated phenolic compounds and an unknown blue-fluorescent compound. Turnips and squash accumulated predominantly coumarin-type compound. A chemical study of the barrier layer (suberin) was initiated with the idea of determining if the chemical nature of the material was related to decay resistance. Micro-chemical tests showed lignin to be a prominent component of the barrier layer.

Plans: The Navy supply studies with lettuce and celery are complete. Additional studies with tomatoes and cucumbers will be made if Navy funds are available. Work on dry bean quality as related to defoliation is complete. Provitamin A studies will be completed with a few more tests and a report then prepared for publication. Studies of the effects of degree and duration of freezing temperatures on tomatoes in the field will be continued as will the work on maturity, holding temperatures and handling practices for mature-green and pink tomatoes.

Chilling tolerances and symptoms studies with acorn squash are nearly completed, but the work with bell peppers will continue at about the level of the past year. Studies on russet spotting of head lettuce will be continued with special emphasis on the effects of environment during growth on the post-harvest development of the disorder. Modified atmosphere studies will be continued, to evaluate a wider range of concentrations and temperatures and to determine the effects of short exposures to high CO₂ concentrations. Determination of respiration rates will be extended to additional commodities as opportunity permits. Storage studies with asparagus roots will be continued through one more season.

Publications: Extending the Storage Life of Cabbage, Celery, Lettuce, and Tomatoes Aboard a Navy Supply Ship. C. S. Parsons. USDA Market Research Report No. 336. June 1959.

Methods to Extend Storage of Fresh Vegetables Aboard Ships of the U. S. Navy. H. T. Cook, C. S. Parsons and L. P. McCulloch. Food Tech. 12 (10): 548-550. Oct. 1958.

Biochemical Studies of Chilling Injury in Sweetpotatoes. M. Lieberman, C.C. Craft, W.V. Audia and M. S. Wilcox. Plant Physiology 33: 307-311. Sept. 1958.

Relationship of Tristimulus Colorimeter Readings to Carotenoid Pigments in Sweetpotatoes. Boyce D. Ezell, Marguerite S. Wilcox and Kenneth D. Demaree. Agricultural and Food Chemistry 7: 44-47. Jan. 1959.

Loss of Vitamin C. in Fresh Vegetables as Related to Wilting and Temperature. Boyce D. Ezell and Marguerite S. Wilcox. Agricultural and Food Chemistry, 7: 507-509. July 1959.

Protection of Paper-Packaged Fruits and Vegetables Displayed on Ice. W. E. Tolle, USDA Marketing Research Report 293. Dec. 1958.

4. POST-HARVEST DISEASES

MQ

Problem: Wastage caused by fungal and bacterial rots occurs at each stage of marketing and causes serious nutritive and economic losses. Identification, mode of action and control methods for decay organisms are important needs.

Program: A continuing program of research in mycology, microbiology and plant pathology with work conducted at Beltsville and in field and market laboratories in Raleigh, North Carolina, Orlando, Florida, Fresno, California, East Lansing, Michigan, Chicago, Illinois, and New York City, New York, and involving approximately 3 professional Federal man-years annually.

Progress: Sweetpotato Decay Control. Solutions containing $\frac{1}{2}$ to 1 percent Sodium orthophenylphenate (OPP) in commercial scale trial applications using both cured and non-cured sweetpotatoes, reduced soft and black rots up to 90 percent. There was no injury to cured roots at these concentrations, but there was some darkening on skinned areas of non-cured roots with solutions containing more than .5 percent OPP. Cured roots were injured at concentrations above 1.0 percent. A very brief water rinse following application reduced chemical injury without reducing control of decay significantly. Residue determinations of OPP on treated roots were made by chemists of the Dow Chemical Company. None of the samples analyzed showed more than 10 ppm OPP.

Peracetic acid, at 500 to 2,000 ppm, reduced soft rot and black rot significantly with tank application, but only black rot was reduced with spray application. Peracetic acid was effective over a wide pH range (3.0 to about 9.0) and over a wide range in concentration without injury to the roots. It decomposed quickly and could not be detected on treated roots within 1 hour after treatment and, therefore, presented no residue problem. However, it was less effective in controlling soft rot than OPP. None of the fungicidal antibiotics tested (Mycostantin, Ascocin, Rimocidin) gave sufficient control of soft rot to be of interest.

Studies on the relation of size of sweetpotatoes to their susceptibility to decay showed that small roots decay less readily when inoculated with *Rhizopus* spores than roots of medium size or larger. Chilling for 4 days at 32° F. either before or after inoculation increased the decay of

all roots. Placing previously chilled roots at 80° or 85° immediately after chilling for a period approximately equal to the chilling period restored the roots essentially to their original conditions as far as decay development was concerned. A delay of several days between chilling and recuring, lessened the effectiveness of the 80° to 85° temperatures.

Watermelon Diseases. Inoculation experiments have shown that all commercial varieties are susceptible to *Phytophthora* rot and that spread of disease by contact occurs frequently.

Pellicularia (*Sclerotium rolfsii*) was serious in shipments from Mexico, California, Texas and Missouri. Infection of melons by this fungus has been reported as occurring only through wounds. Infection of sound melons can be induced by contact with diseased ones. Cultures of the fungus caused infection when placed on uninjured melon surfaces.

Many apparently uninjured melons show glossy, watersoaked areas on their surfaces. Bacteria and yeasts have been isolated. Studies of the organisms are being continued.

Several carloads of California Peacock melons were observed to have growth cracks followed by *Fusarium*.

Black Spot of Radishes. Ten holding tests conducted throughout the 1958-59 season confirmed the results obtained during the previous season. Severity in general increased as the season progressed. Black spot control was attained at 50° F. for periods up to 3 weeks, but color retention was better at lower temperatures. Hydrocooling and subsequent refrigeration during transit and marketing is normally practiced for the prevention of soft rot. Sound application of these practices should control black spot under commercial conditions. Isolations made throughout the season from spotted roots yielded 15 different bacterial cultures. None, however, produced typical symptoms following several methods of inoculations.

Sweetpotato Black Rot. The effect of temperature and method of inoculation on infection and growth of the black rot fungus, in sweetpotatoes was investigated. Lesions developing on inoculated cut halves of roots held at 75° penetrated more deeply than those held at 85°. Inoculation of scratch wounds on whole roots resulted in lesions on the roots at 75° and no lesions on those at 85°. Sections through the lesions showed suberized tissue bounding the lesions that had failed or ceased to grow and the lack of suberization in actively growing lesions. These results further indicate the effectiveness of curing for decay reduction.

Artichoke Decay Control. Tests were made in the 1958-59 season to determine the efficacy of Harven (sodium salt of dehydroacetic acid) and captan against gray mold rot of artichokes. Harven (1,000-8,000 ppm) reduced the decayed area of inoculated bracts by 50 to 70 percent after 13 days holding. The most effective concentration was 4,000 ppm; 8,000 ppm caused injury. The relation of concentration to decay control was

similar at 41, 50 and 59° F., although the total amount of decay increased with increasing temperatures. Captan was tested at 1,250, 2,500 and 5,000 ppm. The best and most consistent decay control was obtained at 5,000 ppm. The use of captan might be limited, however, by a white, powdery residue that remains on the bracts.

Bracts that were injured at the tip to simulate the usual natural injuries, decayed much more rapidly than those left intact. Frequently non-injured bracts without fungicidal treatment, decayed less rapidly than injured bracts treated with a fungicide. Careful handling, therefore, is an effective means of reducing decay. Individual bracts that were inoculated with *Botrytis* spores seldom became infected at the base (point of abscission from the pedicel) although infection was common in wounds made at the tip. The presence of some inhibitory substance at the abscission layer is suggested.

Microbiological Studies with Dry Beans. Studies were initiated to determine the microorganisms, particularly fungi, responsible for microbiological and physiological deterioration of dry beans during storage. Mature beans, aseptically removed from intact pods gathered in the field, were usually found to be free of microorganisms. Isolation studies of fungi from beans stored at various terminals indicated that a number of genera and species of fungi are present, both as external and internal microorganisms. The fungi isolated at the beginning of the storage season were primarily those occurring as soil fungi in the fields where the beans were harvested. Later in the storage season the fungi isolated were those considered to be characteristic storage fungi. These storage organisms were capable of growth at temperatures as low as 35° F. However, growth occurred at these low temperatures only when the moisture content of the beans was well above 18%. The initial fungal growth normally occurs in the surface layer (0-6") where moisture accumulations occur. The majority of fungi isolated during the latter part of the storage season were *Aspergillus* sp. and *Penicillium* sp. Observations were made on the effect of aeration of dry beans in storage in the control of fungal growth. Results indicate that aeration of dry beans of suitable storage condition (less than 18% moisture), decreased the occurrence of storage mold growth by decreasing surface moisture accumulations.

Bacterial Soft Rot Studies. *Pseudomonas marginalis*, the cause of slimy soft rot of lettuce, witloff chicory, escarole and some other vegetables, was irradiated with ultraviolet light. Avirulent mutant strains were produced which differed from the parent soft rot bacterium in their inability to synthesize pectolytic enzymes in culture or to ferment sodium pectate, sodium polygalacturonate or sucrose as the sole carbon source in media. The results indicate that the loss of pathogenicity by the radiation-induced mutants is genetic in nature and is linked with their inability to attack the pectic substrates present in inoculated vegetable tissues.

Conductance Changes With Soft Rot Infection. The electrical conductance of witloff chicory leaves infected by soft rot bacteria was measured. Inoculation with living cells or culture filtrates of *Erwinia* sp. and

Pseudomonas sp. resulted in increased tissue conductance. *Erwinia* sp. caused a much more severe rot and a greater increase in conductance than did *Pseudomonas* sp. An increase in tissue conductance was observed before symptoms developed. An increase in conductance was also observed in advance of the margin of visible lesions. A mutant, non-pectolytic strain of *P. marginalis* was incapable of causing soft rot or conductance changes.

Plans: The work on phytophthora rot of watermelons is completed but other watermelon diseases will be studied. The work on black spot of radishes is virtually completed. The work on sweetpotato and artichoke decays will emphasize commercial applications of control methods. The work on micro-organisms affecting dry beans will be continued to determine the organisms causing storage deterioration, their mode of action and the effects of environmental conditions on deterioration. Work on basic studies of the soft rot bacteria will continue.

Publications: Market Diseases of Beets, Chicory, Endive, Escarole, Globe Artichoke, Lettuce, Rhubarb, Spinach and Sweetpotatoes. G. B. Ramsey, B. A. Friedman and M. A. Smith. Agricultural Handbook No. 155. 1959

Rhizopus Decay of Sweetpotatoes as Affected by Chilling, Recuring and Hydrowarming after Storage. T. T. McClure. Phytopathology 49:359-361. June 1959

Curing of Puerto Rico Sweetpotatoes at 95°F. for Prevention of Black Rot in Storage. L.J. Kushman. Proc. Am. Soc. for Hort. Sci. 73: 467-472. 1959

Pectolytic Enzymes of *Pseudomonas Marginalis* and Their Effects on Lettuce. M. J. Ceponis and B. A. Friedman. Phytopathology 49:141-144. 1959.

Effect of Ultraviolet Light on Pectolytic Enzyme Production and Pathogenicity of *Pseudomonas*. B. A. Friedman and M. J. Ceponis. Science 129:720-721. 1959

Pellicularia Rolfsii on Mexican and Texas Watermelons. G. B. Ramsey, M. A. Smith, L. Beraha, and W. R. Wright. Plant Disease Reporter 43:Sept. 15, 1959

5. MAINTAINING QUALITY OF VEGETABLES DURING TRANSIT

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Problem: Changing containers, transit equipment, shortened rail and truck schedules and incentive rates for heavy loads have raised many questions concerning cooling rates, load patterns and protective services on product quality. These can only be answered by transit tests with the different vegetables from the various producing areas.

Program: A continuing program of applied research with precooling methods and techniques and transit services and equipment. The work involves about 4 professional Federal man-years annually at Beltsville, Maryland and field and market laboratories at Fresno, California, Orlando, Florida, Lansing, Michigan, New York City, New York, and Chicago, Illinois.

Progress: Tomato Quality as Related to Transit Equipment. California green-wrap tomatoes in rail shipments to New York City arrived in better condition when shipped under mechanical refrigeration or in a Cargotemp car than in a conventional fan car. Mechanical refrigeration was very effective in maintaining the temperature of the tomatoes close to the thermostat setting of 55° F. which is the optimum transit temperature for this commodity. The Cargotemp system, which provided thermostatic control of the cold air blast in an ice bunker car, was effective in preventing excessive cooling of the tomatoes when an excess supply of ice was present in the car bunkers. Control of tomato temperature was not quite as close in the Cargotemp car as in the mechanical car. Tomato temperatures in both these cars were more uniform in transit and were nearer the optimum than those in a conventional car iced according to the recommended schedule. Tomato temperatures in the conventional car dropped to 50° F. in transit.

Tomatoes in the mechanical and Cargotemp cars were ripened sufficiently in transit to allow an early sale, whereas those in the conventional car had to be ripened after arrival. Heavy loads, ranging from 34,000 to 37,000 pounds carried well and were provided with adequate refrigeration by the equipment tested.

Asparagus Quality as Related to Transit Equipment. Transcontinental rail tests were made to determine and compare transit temperatures of several commodities shipped in thermostatically controlled ice-refrigerated cars (Cargotemp) with conventional fan cars. The Cargotemp car was developed as a result of earlier research on thermostatic control of air circulation in ice-refrigerator cars.

Transit temperatures of hydrocooled asparagus shipped in a Cargotemp car and in mechanically refrigerated cars remained close to thermostat settings near 35° F. Adequate refrigeration was obtained also in a conventional car shipped under standard refrigeration, but the spread in temperature between layers of the load was considerably greater in the conventional than in the Cargotemp or mechanical cars.

Other data obtained in this test showed no significant build-up of CO₂ in the Cargotemp and conventional cars. Peak accumulations of CO₂ in the mechanical cars ranged from 1.5 percent to 5.8 percent. No injury to the asparagus resulted from these concentrations of CO₂ in the atmosphere of the car.

Relative humidity in the cars ranged from 97 to 100 percent in the Cargotemp and mechanical cars and from 89 to 97 percent in the conventional car.

Cantaloup Precooling. The usual method of precooling cantaloups in California is to rapidly melt top-ice from the load, using either the car fans or auxiliary fans. A few melons are hydrocooled and the use of this method of cooling is increasing. Since little information is available concerning the rate of heat removal from cantaloups by hydrocooling, studies were conducted using a pilot-model hydrocooler.

Temperatures taken by placing thermocouples at various depths in the melons showed that the half cooling time was approximately 2 minutes at the $\frac{1}{4}$ -inch depth and 20 minutes at the $\frac{3}{4}$ -inch depth, while no cooling occurred during 20 minutes at the center of the cavity. Temperature changes at the $\frac{3}{4}$ -inch depth represented average changes for the whole melon, so this location was used in subsequent tests. Rate of cooling did not increase measurably as water flow was increased from 13 to 39 gallons per minute per square foot of hydrocooler area indicating that close to maximum efficiency was reached at 13 gpm. The half cooling time with all rates of flow in this range was about 20 minutes. Neither did the depth of melons in the hydrocooler measurably affect the rate of cooling at the above flow rates. The half cooling time of melons stacked in 1, 2, 3 or 4 layers was approximately 20 minutes. Wetting agents in the hydrocooling water did not increase cooling.

Half cooling times were about the same with initial gradients of 40 to 60 degrees F. between melon and water temperature. Cooling rates of melons that were initially at two different temperature levels, 73 and 93° and which were cooled with water at two different temperatures, 33 and 53°, respectively, (a common initial gradient of 40°) were comparable during 20 minutes of hydrocooling. Apparently, an important factor in the rate of heat removal from cantaloups by hydrocooling is the rate at which heat is conducted through the melon.

Vacuum Cooling Vegetables. The keeping quality of vacuum-cooled sweet corn, asparagus, and cauliflower was observed during a simulated transit and marketing period.

Sweet corn that was wet before it was vacuum cooled was about equal in keeping quality to that which was hydrocooled. Corn vacuum cooled without added water cooled about as well as that wet before vacuum cooling, but the husks were not as fresh and denting of the kernels was more prevalent than in pre-wet corn. Top-icing the corn after cooling aided greatly in preserving freshness in all lots.

Asparagus vacuum cooled wet kept as well as hydrocooled asparagus. Pre-wetting had little effect on the final temperature of vacuum-cooled asparagus, but reduced weight loss.

Trimmed cauliflower that was film-wrapped before vacuum cooling and that wrapped after hydrocooling showed no difference in keeping quality. Pre-wetting the cauliflower before wrapping and vacuum cooling improved the rate of cooling.

Lettuce packed in polyethylene box liners cooled less than lettuce without liners during vacuum cooling. Perforation of the liner had no effect on the rate of cooling. Lettuce in perforated individual-head bags cooled nearly as well as that in conventional cartons. In unperforated bags with folded closures pressed down under the heads during packing, final lettuce temperatures averaged 44.5° F. or 6 degrees higher than in perforated bags. Practically no cooling occurred in sealed unperforated bags. Weight loss in all lots of lettuce during vacuum cooling was proportional to the reduction in temperature.

Four shipping tests of lettuce and two of corn were conducted to determine the results of vacuum cooling after loading, of entire truck trailers loaded with New York State-grown lettuce packed in cartons and corn in wirebound crates. Temperatures of lettuce were lowered in 35 to 43 minutes to average below 40° F. from a start of 69° to 86°. Weight losses of lettuce, following vacuum cooling and shipment from Pine Island, N. Y. to Baltimore, Md. and Washington, D. C., averaged 3.4 to 4.8 percent. Corn temperatures ranging from 78° to 86° at loading in 2 truck shipments were reduced about 45° by the vacuum process in 49 to 55 minutes. All shipments arrived at market in acceptable condition.

Bunker Salting as Related to Transit Temperatures of Lettuce. The time of adding initial salt to the bunker ice was compared in three paired refrigerator car tests from Salinas, California to eastern markets. One car from each pair received 2 percent initial salt (based on the ice capacity of the car) at shipping point while the other received 2 percent initial salt at the first re-icing station (Roseville). All cars in the first two paired tests received 3 percent salt (based on amount of ice added) at each re-icing station subsequent to that where initial salt was added. The third pair of cars received 2 percent salt at each re-icing.

In each of the tests, the lettuce in the car in which initial salting was delayed until re-icing at Roseville warmed up slightly during the first few days to about 1 degree F. warmer than the lettuce that received initial salt at shipping point. After the second or third day in transit, however, lettuce in cars in which initial salting was delayed, cooled 1 to 3 degrees more than that in cars that received initial salt at Salinas. This temperature difference was maintained for the remainder of the trip.

Average trip temperatures of lettuce in each of the six cars were within a range of 34° to 38° F. Average temperatures did not differ greatly in relation to the time of salting, but were slightly lower in the cars in which salting was delayed. This practice also helped avoid sub-freezing temperatures at the coldest positions in the cars (bottom bunker air) during the time the cars were standing at shipping point.

Effect of Trimming on Market Quality of Lettuce. Western shippers are faced with the problem of an increase from the present 43-pound billing weight for carton-packed lettuce. Tests were conducted at the request of the Western Grower's Association in the Salt River Valley, Arizona and the Imperial, Palo Verde, and Salinas Valleys of California to determine the effect of various degrees of trimming on packed weight and arrival condition of 2 maturities of lettuce shipped to New York.

Weight: Average weights of hard lettuce trimmed to 8 wrapper leaves were 59.2 pounds before vacuum cooling and 57.4 pounds after cooling. Respective data for hard lettuce trimmed to 6, 4, and 2 wrapper leaves were 56.0 and 54.2 pounds, 51.5 and 50.2 pounds, and 47.4 and 46.2 pounds. Fairly firm lettuce trimmed to 8, 6, 4 and 2 wrapper leaves weighed 52.7 and 51.3 pounds, 48.3 and 46.7 pounds, 43.9 and 42.4 pounds, and 39.2 and 38.0 pounds, respectively. Fairly firm lettuce, therefore, was brought

close to the present 43 pound billing weight by trimming to 4 wrapper leaves, but the weight of hard lettuce could not be reduced sufficiently to meet the billing weight even by trimming to only 2 wrapper leaves.

Carton Closures. Average carton-closure gaps for lettuce trimmed to 8, 6, 4, and 2 wrapper leaves were 3.3, 2.7, 1.9, and 1.4 inches, respectively, for hard lettuce and 3.1, 2.4, 1.8, and 1.3 inches for firm lettuce. Only lettuce trimmed to 4 or less wrapper leaves brought closures within the 2-inch regulation now in effect in California.

Arrival Condition. Trimming to the various numbers of wrapper leaves appeared to have no effect on the quality of lettuce on arrival or after holding at New York. Crushing and bruising, decay, and useable lettuce was about the same in the various trims. On arrival in New York crushing was rated as a trace to slight, decay averaged about 0.2 percent, and useable lettuce remaining after removal of defective leaves averaged 84.3 to 88.1 percent. After holding 5 days at 50° F. crushing was rated as slight, decay averaged about 1.2 percent and useable lettuce remaining was 80.5 to 82.7 percent. Maturity appeared to have little effect on the above defects, although slightly more decay developed in hard than in firm lettuce during holding at the market.

Shipment of Tomato Plants as Related to Packaging. Tests to evaluate polyethylene crate liners for shipping bare-rooted tomato transplants from Georgia to northern production areas were continued. Seven shipping tests using ice-bunker and mechanically refrigerated trucks were made from Georgia to Ontario, Canada in cooperation with the Campbell Soup Company. As reported last year, bare-rooted plants packed in polyethylene-lined crates arrived in good condition, and about equal to plants packed the conventional way with roots in moist peat and a kraft paper wrap around each bundle. Field survival and yield data are not yet available. The 1.5-mil film liners used in the wirebound crates holding 700-800 plants had 32 1/2-inch ventilation holes and a folded closure at the top. Some crates were field packed with bare-rooted plants in polyethylene for comparison with plants later sorted and packaged in a packing plant. Arrival condition of the field-packed plants was good.

Transit temperatures of bare-rooted plants in polyethylene liners averaged 2-4 degrees warmer than of plants in unlined crates. More satisfactory transit temperatures (50-60° F.) were obtained in ice-bunker trucks than in mechanically refrigerated trucks with thermostats set at 50° F. In one test with a mechanically refrigerated truck, arrival temperatures of 80° F. at top-doorway positions were 10 degrees higher than at departure. Inadequate air circulation space at the ceiling and rear door were frequent causes of poor transit refrigeration. Pre-iced trucks, re-iced when necessary to keep bunkers at least half full, and with vents closed, gave good transit refrigeration, if air-circulation space around the load was provided.

Hydrocooling Vegetables. The rate of cooling of cabbage, okra and pink tomatoes was determined during hydrocooling in water maintained at 40° F. Cabbage temperature was reduced from 83° to 60° in 15 minutes when the heads were arranged in a single layer. Cooling was only 2 to 3 degrees less when the heads were two and three layers deep. Increasing the treatment period to 25 minutes cooled the cabbage only 3 degrees below that obtained in 15 minutes. Okra, packed in 1/2 bu. hampers, cooled uniformly and rapidly from 87° to 48° in 10 minutes. Pink tomatoes (4 x 5's), in 8 inch deep packing crates, cooled from 87° to 60° in 15 minutes. Hydrocooling pink tomatoes before packing appears to have commercial possibilities.

Transit Protection of Winter Vegetables Moving to Northern Markets. These studies are being conducted to provide adequate conditions for refrigeration during the early part of the trip and protection from freezing as the car moves North. It was possible to obtain only two test cars during the season because excessive rainfall in Florida and poor market conditions limited shipments to Canada. From this limited data it appears that 3 tons of top ice may be sufficient unless very high temperatures prevail at loading point.

Bulk Shipment of Dry Beans. The relation between initial product quality of pea beans, at country elevators, and delivered quality at processing plant was studied in 3 tests to compare bulk shipments in an insulated car especially altered for dry bean shipments with shipments of beans in box cars. The insulated car minimized temperature fluctuations, which is not only beneficial in preventing increases in cracked seed coats, but materially reduces the tempering time for the processors since beans must enter the soaking vats at near room temperature.

The September 1958 shipment from Saginaw, Michigan, to Pittsburgh, Pennsylvania made during warm weather consisted of one standard box car containing bagged beans and one insulated bulk car altered by insertion of floor panels at a 22° slope from the ends to the center. During the 5-day transit period moisture content of beans in bags increased from 17.92 to 19.10 percent, an increase of 1.18 percent, while those in the insulated car gained 0.77 percent. Cracked seed coats increased 1.8% in bagged beans and 0.34% in the bulk.

In October 1958 another shipment was made. The insulated car had been further altered by addition of 6 loading hatches and the angle of floor slope lessened to increase the car capacity. Shipment of 19% moisture content beans reduced seed coat cracks and splits to a minimum. Temperatures were very uniform in the insulated bulk car ranging from 54 to 56° F. In the bagged load the temperature ranged from 48 to 65° F.

The January 1959 shipment moved during a period when outside temperatures ranged from 2° to 40° F. At destination bagged beans ranged from 14-45° F. with the larger portion of the load below freezing temperatures while the temperature in the insulated bulk car ranged from 28 to 40° F. Damage from

cracked seed coats was excessive, probably because of faulty equipment and below freezing temperatures. Seed coat cracks increased more in bagged than in bulk shipments.

Plans: Studies on the effect of trimming on lettuce and on asparagus quality as related to transit equipment have been completed. The work on bulk shipment of dry beans by rail and truck will soon be completed. Another season's test will probably complete the work on shipment of tomato plants. Further studies will be made to develop protective services for tomatoes moving by the recently inaugurated faster rail schedules. Studies on vacuum cooling of prepackaged celery and other vegetables will be made. Studies on bunker salting practices for lettuce, hydrocooling of cantaloups and other vegetables, and transit protection of winter vegetables moving to northern markets will be continued.

Publications: Commercial Hydrocooling of Cantaloups Tested. W. J. Lipton and J. K. Stewart. Western Grower and Shipper 30 (6): 14-16.

Transit Temperatures of California Lettuce. W. R. Barger, J. K. Stewart, J. M. Harvey, M. J. Ceponis, Leonard L. Morris and R. F. Kasmire. USDA Marketing Research Report No. 285. 1958.

Transit Temperatures of California Mature-green Tomatoes Shipped by Rail. A Comparison of Mechanical, Cargotemp, and Conventional Refrigeration. W. R. Barger, J. M. Harvey, and S. M. Ringel. USDA Marketing Research Report No. 349. 1959.

Bulk Shipping of Navy Beans. J. A. Thompson. USDA Agricultural Marketing, 3 (8):5. August 1958.

Providing Specific Transit Environments Consistent with Commodity and Market Requirements. A. L. Ryall. Proceedings Tenth International Congress of Refrigeration. August 1959.

What's Ahead in Heavier Vegetable, Melon Loads? A. L. Ryall, USDA. Western Grower and Shipper 30 (2): 16, 27, 28, 31. Feb. 1959.

6. CONTROL OF INSECTS IN PROCESSING PLANTS

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Problem: No satisfactory method is available to remove insects, insect fragments, and insect-damaged kernels from fresh corn during processing.

Program: This is a 3-year program on the development of a suitable means for removing insects and other contaminants of sweet corn during processing for canning, being conducted under contract by the Ohio Agricultural Experiment Station at Wooster, Ohio.

Progress: A rapid method of detecting and counting insect fragments was perfected. A combination pyrethrum treatment and a detergent wash was developed to remove insects and insect fragments from fresh corn. This method, however, was only 98-percent effective and thus allowed some contaminants to pass through into the finished product.

Plans: This study will be continued for the third and final year. Corn after treatment will be cooked and served to a taste panel to determine whether off flavors are produced. Results of the study will be published by the contractor.

D. Transportation, Storage, and Packaging

7. IMPROVED CONSUMER PACKAGES, SHIPPING CONTAINERS, AND METHODS OF PACKAGING VEGETABLES

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Problem: Climbing costs of labor, packaging materials, transportation rates, high waste and spoilage losses, and frequent expressions of consumer dissatisfaction with some prepackaged vegetables emphasize the need for improving the packaging of fresh vegetables as economically as possible.

Program: A continuing and varied program--in terms of shifting attention from a commodity on which research has been completed to other vegetables--to (1) develop new or improved consumer packages and shipping containers; (2) evaluate packages, containers and packaging materials; (3) determine at which point in the marketing system the packaging can be done most effectively; (4) improve efficiency of packaging methods; and (5) investigate the needs for and benefits of container standardization and simplification, carried on in cooperation with container manufacturers and growers and distributors in the main vegetable producing areas and in the principal markets, in cooperation with State Experiment Stations of California and Arizona, involving 3 professional Federal man-years annually.

Progress: Asparagus Prepackaged at Point of Production. Very limited experiments were conducted in Washington State during the past year in which 7-inch asparagus was trimmed to edible 5-inch portions and prepackaged in poly bags. The trimmed portion, 35 percent reduction in weight, represents a considerable potential savings in shipping weight and space requirements. However, the cost of packaging materials, including the master containers, poly bags, and plastic closures amounted to 53 cents for 24 bags, or 3.4 cents per edible pound of asparagus. This compared with 45 cents for packaging materials for 30-pound bunched asparagus packed in a pyramid crate, or 2.3 cents per edible pound of asparagus. Labor cost for prepackaging asparagus was 2.3 cents per edible pound as compared to .5 cents per edible pound for packaging it in bunches in pyramid crates. Therefore, it cost approximately 3 cents more per edible pound to prepackage asparagus in poly bags than to bunch pack it in pyramid crates. The prepackaged asparagus was sold locally. No work has yet been undertaken to evaluate the possible savings in transportation and refrigeration costs for prepackaged asparagus if shipped across the country from major producing areas, such as California to New York.

Cauliflower Prepackaged at Point of Production. A 3-year project prepackaging California cauliflower was completed during the past year. The prepackaged cauliflower was fully trimmed and only the curds were packaged in cellophane or cellophane laminated with aluminum foil. The prepackaged cauliflower was shipped in three different types of fiberboard

boxes--a single layer full telescope box; a double layer regular slotted carton; and a 1-piece open top fiberboard box. Of the three major types of master containers used for prepackaged cauliflower, the 1-piece regular slotted carton double layer box was the most economical and protected the cauliflower as well as the other two containers. The cost of packaging materials and labor to prepackage cauliflower is, of course, greater than to bulk pack it, untrimmed, in conventional WGA crates. However, savings in freight, refrigeration, and bracing materials were more than enough to offset additional packaging materials and labor costs. On a 100 pound of edible cauliflower basis, the total cost of packaging materials and labor to prepackage cauliflower, plus freight, refrigeration and bracing materials, amounted to \$7.42 if shipped in double layer regular slotted boxes as compared to \$8.97 for packing and shipping cauliflower in WGA crates, \$9.34 for packing and shipping cauliflower in Pony crates, \$7.60 for packing and shipping closely trimmed cauliflower in wood flats. Therefore, \$1.55 per 100 pounds of edible cauliflower can be saved by prepackaging and shipping it in double layer boxes as compared to packing and shipping it in conventional WGA crates.

Nineteen test shipments containing prepackaged and bulk packed cauliflower were also made during the year. The prepackaged cauliflower showed considerably less serious bruising--0.4 percent, as compared to 4.2 percent for the bulk packed cauliflower. Discoloration and slight bruising was also less for prepackaged cauliflower than for the bulk cauliflower. It appears, therefore, that the economies in transportation and refrigeration costs enable California cauliflower shippers to market their cauliflower more economically in prepackaged form than in bulk form. To what extent this would be possible in other areas, such as Colorado or Long Island, would depend, of course, on relative savings of packaging materials and in costs of transportation.

Lettuce Field Trimming. Previous studies indicated that excessive bruising was likely to occur whenever more than $1\frac{1}{2}$ pounds of lettuce were packed per 100 cu. in. of capacity. By trimming wrapper leaves off of the lettuce in the field, the weight per carton is reduced about 2 pounds for each wrapper leaf removed from each head in the carton. For example, a fiberboard box of lettuce with 6 wrapper leaves per head would weigh 4 pounds less than a box with 8 wrapper leaves per head. A number of tests were made in cooperation with the Market Quality Division and the Universities of California and Arizona, to determine the relationship of market quality and gross weight of the packed boxes of lettuce to maturity and amount of field trimming. The economic effect of trimming off more wrapper leaves in the field is obvious by comparing the extra cost for freight for shipping 640 boxes of lettuce weighing 47 pounds as compared to 49 pounds--2 pounds less weight would result by removal of one additional wrapper leaf. The freight would amount to \$782 for the lettuce with a billing weight of 47 pounds as compared to \$815 for 49 pounds. In other words, \$33 freight could be saved by trimming off one additional leaf. Under the new 30,000-pound incentive rate basis, it would cost \$752 per car if the lettuce carton carried a billing weight of 47 pounds as compared to \$784 per car for a 49-pound billing weight.

The extra cost of labor required to harvest lettuce at an earlier maturity or if trimmed to 3 to 5 wrapper leaves, as compared to the present practice of trimming to a maximum under 6 wrapper leaves, has not yet been determined.

Green Beans Prepackaging at Point of Production. Preliminary experiments were undertaken in Florida during the past year in which green beans were prepackaged in poly bags, polymer coated cellophane bags, and chipboard trays overwrapped in polymer coated cellophane. Green beans were both hydrocooled and vacuum-cooled. Some were shipped in wirebound crates and some in moisture-resistant wax-coated fiberboard boxes. Some were shipped with top ice and some with standard refrigeration. They were shipped by rail from Florida to New York City, and remained in excellent salable condition from 4 to 7 days after arrival. The vacuum-cooled green beans remained in better condition than the hydrocooled beans. Those packaged in polymer coated cellophane appeared more attractive and more salable, because of less moisture condensation than those packaged in poly bags.

Celery Prepackaging at Point of Production. Experiments were also undertaken during the past year in prepackaging celery at point of production in Florida and California. Celery hearts were prepackaged in cellophane bags and the large stalks of Pascal celery were prepackaged in poly bags with the tops left open. The celery was both vacuum-cooled and hydrocooled. Considerable savings, primarily due to lower labor cost and savings in rehandling labor, can be effected by prepackaging celery at point of production instead of retrimming and repackaging it in terminal markets. On the basis of these limited experiments, plants are being set up in Florida and California, by a large chain store organization to prepackage about 6 carloads of celery per day during the coming season for packing and shipping prepackaged celery to eastern markets.

Sweet Corn Prepackaging at Point of Production. Considerable research has been previously undertaken to prepackage fully husked sweet corn at point of production, although due to inadequate refrigeration facilities and practices, it was not widely adopted commercially because of the difficulty of maintaining corn in satisfactory condition. Research was again initiated in Florida during the past year, in which sweet corn was prepackaged in poly bags, on backboard trays overwrapped with polymer coated cellophane, and in polymer coated cellophane bags. The outer husks were removed but the inner husks were left intact except for a narrow strip to reveal the corn to consumers. The sweet corn was both hydrocooled and vacuum-cooled. Vacuum-cooled offered a very important advantage in that the temperature of the corn could be more quickly reduced to desirable levels around 35 degrees. Too much time, to be commercially practicable, was required to hydrocool the corn down to this desirable temperature. Some of the prepackaged corn was packed in moisture resistant fiberboard boxes with bunker ice only and some was shipped in wirebound crates which were top iced. The most attractive package was the backboard tray with the stripped portion of the corn placed upward and overwrapped with polymer coated cellophane. However, the

polymer coated cellophane and paperboard tray do not lend themselves too well to the high humidity caused by the packaged ice or top ice. Polyethylene, of course, was not adversely affected by the high humidity or the ice. Some of the corn was wet before placed in the package, then vacuum-cooled and then the packages were again immersed in water to wet the corn after vacuum-cooling. These preliminary tests indicated that the safest way to prepackage sweet corn and assure adequate refrigeration is to: Partially strip-it--wet it--package it in poly bags--vacuum cool it--pack it in wirebound crates with "package ice" and ship it under top ice. On the whole, prepackaging of sweet corn looks very promising if adequate refrigeration practices can be developed.

Leafy Vegetables (Escarole, Chicory, and Chinese Cabbage) Prepackaging at Point of Production. Leafy vegetables were also prepackaged in polymer coated cellophane and in poly bags in Florida, and were shipped to New York City during the past season. The preliminary experiments indicated that dehydration losses of these leafy vegetables could be reduced by prepackaging in semi-moistureproof film and that adequate shelf life appeared promising if they were properly refrigerated.

Cantaloup Shipping Containers Improved. In this research three new types of containers, including one wood container, one wirebound and one fiberboard container, were evaluated against the conventional wood shipping container. All three new containers sustained significantly less damage in shipment and delivered more bruise-free melons than the conventional jumbo crate. Packing and transportation costs were reduced as much as 7 cents per crate through use of a new fiberboard container for the melons. Container damage in shipments of the new fiberboard box was only one-fifth of that normally found in shipments of the old wood crates, while melon bruising was only about one-tenth as much. The new wooden crate reduced container damage about two-thirds and melon bruising more than half. Also of particular significance is the fact that the new containers were found to lend themselves very effectively to heavier loading of rail shipments which will enable the shippers to reduce their per-package transportation and refrigeration costs through use of the incentive freight rates for heavier loads.

Plans: Work will be continued and increased emphasis will be given to development of packages and containers and methods of prepackaging vegetables near the point of production. This includes research on prepackaging asparagus, broccoli, sweet corn, green beans, celery, leafy vegetables, and tomatoes. Attention will also be given to developing improved shipping containers for vegetables, such as the moisture-resistant fiberboard boxes currently being developed and tested. The work on the cantaloup shipping container project has been completed and the report on this research is now being reviewed for publication.

Publications: Produce Packaging Prospects. Donald R. Stokes, USDA. Produce, Marketing, No. 10, Vol. 1. 30 October 1958.

New Breakthroughs in Produce Packaging. Donald R. Stokes, USDA. Processed paper presented at the Southwestern Michigan Packaging Show for Growers and Shippers of Fresh Fruits and Vegetables, Berrien Springs, Mich. on March 19, 1959.

Fresh Produce Prepackaging Practices in the United States. Thomas B. Smith and Juan Jose Valldejuli, USDA Marketing Research Report No. 341. July 1959.

Central Packaging Operations. Donald R. Stokes, USDA. Processed paper presented at the Eleventh Annual Merchandising and Management Conference of the United Fresh Fruit and Vegetable Association, Chicago, Ill., September 1, 1959.

The Next Ten Years of Produce Packaging. Donald R. Stokes, USDA. Processed paper presented at the Annual Convention of the Produce Packaging Association, Philadelphia, Pa., September 16, 1959.

New Melon Containers Show Promise. William R. Black, USDA. Western Grower and Shipper, November, 1957.

New Melon Containers Cut Costs. P. L. Breakiron, USDA Agricultural Situation, July, 1958.

8. IMPROVED LOADING METHODS FOR TRANSPORTATION OF VEGETABLES AND MELONS TF

Problem: Increasing freight and protective service costs, heavy losses from spoilage, damage and reduced shelf life because of ineffective refrigeration and ventilation during transportation have greatly increased marketing costs for many vegetables and melons in recent years. More efficient loading methods that can be used with little or no additional cost to shippers can provide better protection for containers and products, facilitate better refrigeration and ventilation during transit and facilitate more effective use of available loading space in the transportation vehicles, leading to reduced per-package transportation and refrigeration costs.

Program: A continuing and varied program of work involving test shipments by rail and by truck. The research involves the development and testing of new loading patterns, load securing equipment, measurement of container and product damage, air velocity, temperature differentials, and labor requirements for loading and unloading. It is carried out with the informal cooperation of shippers, receivers, railroads, truck lines, container and loading equipment manufacturers, and other interested groups and involves about 1 professional Federal man-year annually.

Progress: To determine the feasibility of heavier loading of long-type watermelons in rail shipments to reduce per-melon transportation costs, total of 5 test shipments of the Charleston Gray variety of watermelons was made from South Carolina and Virginia during the year. The number of melons in the loads ranged from about 1,500 to more than 2,200, depending

upon the average size of the melons. In the tests 5, 6, and 7 layer loads were tried, which compares with the usual loads of 4 and 5 layers for melons of comparable size and weight ranges. The results of these limited tests suggest that it may be entirely feasible to ship sound melons in loads which are from 25 to 50 percent heavier with about the same percentage of damage under normal transit handling conditions. However, further tests during several years are needed before recommendations can be made.

Plans: Additional watermelon shipping tests on a considerably larger scale from Florida, Georgia, South Carolina, and Virginia are planned for next season. Research to develop new loading methods for heavier loads of tomatoes is planned for the next year.

9. AERATING, HANDLING, AND STORAGE OF DRY EDIBLE BEANS AND PEAS IN COMMERCIAL STORAGE

TF

Problem: Changes in harvesting methods and the shift from bag to bulk storage emphasize the need for developing new and economical methods, equipment, and facilities for conditioning, handling, and storing pea beans in bulk.

Program: A 5-year research program to evaluate and improve storage and handling practices in the dry edible bean industry conducted through a field office located at East Lansing, Michigan in cooperation with the Michigan Agricultural Experiment Station and commercial elevators located in Michigan at a rate of 2 professional Federal man-years per year. This research program was discontinued on June 30, 1959.

Progress: Handling Bulk Beans. Limited studies were made of bagging, sewing, and handling 100-pound bags of beans in elevators in Michigan. A 4-man bagging crew consisting of bagger, sewer, stacker and transporter was productive only about 57 percent of the time using the existing method of bagging. Elimination of the stacker and improvement in crew balance increased the productivity of the crew, now consisting of 3 men, to nearly 90 percent. With the improved method of bagging, the 3-man crew was able to increase the rate of bagging by 61 bags per hour over the old method. A 3-man crew bagged 300 bags per hour with a dolly-model sewing machine and a semi-automatic floor scale with each man performing a single operation. A 2-man crew also bagged 300 bags per hour with the same equipment but at a saving of \$500 per year. In the latter case, the sewing operator also stacked the bags on a hand truck; thus, the amount of unproductive labor was reduced from about 42 percent to 7.5 percent. It was found that further savings were possible with the use of conveyor-or portable-type sewing machines.

In additional tests of bean cleaners, changes in the scalper screen and in the vibration rate of the cleaning shoe increased the average cleaning rate from 545 up to 633 bushels per hour with beans having similar amounts of foreign material. The draft for a final report on the handling studies is nearly complete and soon will be submitted for review and publication.

Aeration of Stored Beans. Aeration studies were continued in both flat and upright storages to obtain additional information on acceptable aeration practices under varied weather conditions and on design principles for satisfactory aeration systems. An airflow rate of 1/10 cubic feet of air per minute (cfm) bushel continued to be satisfactory in preventing "hotspots" and moisture accumulations in surface layers of bulk-stored pea beans with moisture content of 18 percent and lower. Airflow rates up to 1/5 cfm per bushel were demonstrated to be practical for flat storages where static pressures are lower and airflow not as uniform as in upright storages. Research data indicates that a temperature range between 45° and 32° F. allows adequate fan operation for satisfactory aeration under most weather conditions encountered in the Michigan area; also, that fans should not be operated for any length of time when the relative humidity of the air is above 80 percent. Uneven distribution of the air was noted in flat storages where the maximum air velocity within the duct exceeded 1,500 feet per minute resulting in nonuniform cooling of the stored beans. Also, considerable unevenness of airflow was noted in flat storages where the spacing of the ducts was from 50 to 100 percent greater than the depth of the stored beans. The draft for a final report on the aeration studies is nearly complete and soon will be submitted for review and publication.

Plans: As this project has been discontinued, no plans are indicated.

E. Equipment, Facilities, Methods and Firm Efficiency

10. IMPROVED METHODS, EQUIPMENT, PLANT LAYOUT AND DESIGN FOR HANDLING AND PROCESSING FRESH VEGETABLES TF

Problem: Develop more efficient methods, devices, and equipment and design improved facilities for conditioning, handling, and preparing vegetables for market.

Program: A long-term research program conducted by the Washington office on terminal markets and by the Gainesville, Fla. field office at shipping points, in commercial packing plants and laboratory facilities of the University of Florida, in cooperation with the Florida Agricultural Equipment Station on work at shipping points and with the Marketing Economics and Market Quality Research Divisions, at the rate of 2 professional Federal man-years annually.

Progress: Handling and Packing Tomatoes in Terminal Markets. Data on sorting, packing and related operations associated with repacking tomatoes were obtained from 4 plants during the year to complete the field work. Studies included the determination of man-hour requirements for 3 major types of sorting equipment and 2 types of tray filling equipment when a number of different work methods were used. Four methods of repacking tomatoes in 10- and 20-lb. containers were also studied. In most cases data were obtained for 2 different crew sizes for each of the sorting and tray filling methods observed. Summary tables of man-hour requirements for the sorting and tray packing

operations by these methods are being prepared. Statistical techniques are being used to check the accuracy of the data obtained. Studies of physical damage to tomatoes caused by different methods of handling were made under simulated conditions in the Beltsville laboratories.

Handling and Packing Vegetables at Concentration Points. Work in Florida vegetable packinghouses was limited to the development of work plans for the 1959-60 season.

Plans: An analysis and comparison of labor and equipment requirements and costs for the sorting, tray packing, and repacking methods studied will be presented in a final report, together with an evaluation of a number of sorting and tray packing systems. One section of the report will be devoted to the problems of ripening and physical damage to tomatoes that occur during processing by the repacker.

Surveys will be made of representative tomato packinghouses in each major producing area of Florida. Survey procedure will include: Preparation of plant layout; flow-process analysis; and description of equipment, methods, and crew organization. Based on survey information, selected operations or groups of operations will then be studied to determine possibilities for improvements in work methods, crew organization, equipment, and facilities.

11. IMPROVED METHODS, EQUIPMENT, PLANT LAYOUT AND DESIGN FOR HANDLING AND PROCESSING FROZEN VEGETABLES

TF

Problem: Increase the productivity of labor and reduce quality deterioration in wholesale frozen food warehouses and processing plants.

Program: A five year program of research, carried on by the Washington office, in the selected plants of cooperating firms throughout the United States, at the rate of one professional Federal man-year annually.

Progress: Field work on the study to compare the relative efficiency of five types of refrigeration equipment used for freezing vegetables has been substantially completed.

Studies of manual and automatic casing operations for retail packages of frozen vegetables and the palletizing of cases were made concurrently. Raw data have been checked for statistical validity and organized for further analysis. However, the analysis has not progressed to the point that findings are available.

Plans: Studies of freezing methods and equipment and casing operations will be completed. Analyses based on labor and equipment costs will be prepared. A report presenting the results of this work will be drafted.

Publications: Mechanically Processing Wholesale Frozen Food Orders. T. H. Allegri and R. K. Bogardus. AMS-317, June 1959.

F. Costs, Margins and Organization of the Marketing System

12. CHANGES IN METHODS OF MARKETING

ME

Problem: Vegetable industry leaders need more accurate information on the changes taking place in wholesale markets for fruits and vegetables in order to evaluate the impacts of these changes on the vegetable industry and to assist in making decisions and recommendations for adjustments to meet these changes.

Program: A 3- to 4-year research program involving about four professional Federal man-years annually, in cooperation with the Agricultural Experiment Stations in Wisconsin, West Virginia, Oregon, Kentucky, Maine, Montana, New York, Utah, and Oklahoma, and through contract studies in the San Francisco market area by the University of California, Berkeley, California and in the Pittsburg market area by Midwest Research Institute, Kansas City, Missouri.

Progress: Sharp increases have occurred in direct buying by retailer groups (both corporate and voluntary) and, to some extent by service wholesalers and other types of wholesale handlers. The number of retailing groups large enough to take advantage of direct buying has grown until they now handle a major portion of the retail food business.

Field work is now underway for a study of the present status and organization of about 20 wholesale fruit and vegetable markets throughout the country. This information will provide the basis for a description of changes in wholesaling fresh fruits and vegetables and an analysis of the future role of terminal markets in wholesaling fresh fruits and vegetables in the years ahead.

A study which analyzes the organization and marketing practices for vegetables grown in the east Texas area has been completed and is being published by the Texas Agricultural Experiment Station.

Plans: Study of changes in methods of marketing vegetables will continue in cooperation with interested Agricultural Experiment Stations.

Publications: The Changing Role of the Fruit Auction. Alden C. Manchester, USDA Marketing Research Report No. 331, June 1959.

13. EVALUATION OF THE PROCESSING MARKET FOR SOUTHERN VEGETABLES

ME

Problem: Vegetable growers and processors need more information about the economic feasibility of processing vegetables grown in the South. Growers need information to assist in their evaluation of processing as a market outlet.

Program: A 3- to 4-year program of applied research being carried out in cooperation with the North Carolina and Louisiana Agricultural Experiment Stations as a phase of the Southern Regional Vegetable Marketing Research

project, involving one professional Federal man-year annually and located at Raleigh, North Carolina.

Progress: Detailed plans for a study of the cost and economic efficiency in canning sweetpotatoes have been completed and work is now underway in plants in North Carolina and Louisiana. There are no findings to report.

Plans: The study will continue in cooperation with the North Carolina and Louisiana Agricultural Experiment Stations.

14. MARKETING WESTERN FROZEN FOODS

ME

Problem: The effects of increased competition between the major producing areas is of great importance to the frozen food industry. Producers, frozen food packers and others need more information on the production and processing costs and trends in the industry as guides in formulating their future plans.

Program: A 4- to 5-year study in cooperation with the California and Oregon Agricultural Experiment Stations as a part of a Western Regional Marketing project, utilizing two professional Federal man-years per year and located in Berkeley, California and Corvallis, Oregon.

Progress: Particular attention is given to an analysis of physical and economic relationships in the assembly of product and in freezing operations for green peas, lima beans, and spinach. Analysis is underway of the effects on costs, of such factors as handling and processing methods and plant organization, number and type of products frozen by a single plant, length of operating season, plant location and scale of operation.

Substantial progress has been made in developing costs of handling and freezing lima beans, green peas, and other vegetables. In addition to providing detailed costs of handling and freezing operations for lima beans for freezing, the study showed that programing of vining and plant operations had an important effect on costs. Length of operating season up to about 750 hours per season also had a marked effect on costs.

Plans: The work will be continued in cooperation with the California and Oregon Agricultural Experiment Stations as a phase of the Western Regional Marketing project.

Publications: Economic Efficiency in Assembly and Processing Lima Beans for Freezing. Robert H. Reed, Calif. Agri. Exp. Sta. Mimeo, Report No. 219, June 1959.

How to Improve Operating Efficiency in Food Processing Plants. H. M. Hutchings and G. B. Davis. Ore. Agri. Exp. Sta. Misc. Paper 77, August 1959.

Costs and Efficiencies in Pea Freezing Operations. Part 1. Vining. G. B. Davis and H. M. Hutchings. Ore. Agri. Exp. Stat. Misc. Paper 66, January 1959.

Processing Limas for Freezing. Robert H. Reed. California Agriculture, Vol. 13, No. 6, June 1959.

Plant, Field Vining Compared. Oregon Agricultural Progress, Winter, 1959.

15. IMPROVED PRICING METHODS

FCS

Problem: Improved pricing plans and grower payment methods are needed to more accurately reflect changing market requirements back to growers and grower organizations so as to better balance supplies with demand. Changing industry organization and procurement practices required by mass distribution are bringing about more complex product specifications, and has altered pricing techniques which reduce the effectiveness of conventional pricing methods.

Program: This continuing long-range program of applied research, part of which is contributing to the Western Regional Project WM-38, is conducted for major production areas, involves about 2 professional Federal man-years annually, and is conducted in cooperation with former cooperatives and other processing and marketing firms.

Progress: Improving Pooling and Payment Practices for Producers. A report has been completed and submitted for publication. It was found that vegetable cooperatives, like other associations using a pooling method for paying growers, were in the best position to capitalize on the changing market structure. In contrast to those handling products as individual lots, these cooperatives handled a greater number of commodities, offered more services to their members, had the greatest opportunity for developing an orderly marketing program, and relied more heavily upon a grower-member contract to integrate the production practices of growers with their association's marketing requirements. By handling a greater number of commodities, pooling cooperatives provided more product diversification; by providing a complete set of marketing services, they more fully utilized alternative marketing outlets; and by relying more heavily upon cooperative marketing contracts, they were assured of more stable supplies upon which to develop a sounder sales program.

Fruit and Vegetable Bargaining. Building on information obtained in the first phase of this study (which was reported in FCS Circular 25), preliminary work is underway to analyze the impact of bargaining associations on the structure and behavior of the fruit and vegetable processing industry, measuring the effects of amounts paid for raw product, and other contract terms, and their influence on scale of operation and on the trend toward vertical integration.

Again at the request of growers, a Third National Conference on Fruit and Vegetable Bargaining was arranged and conducted by Farmer Cooperative Service in January 1959 in New Orleans. A proceedings of the conference, which included findings from this study, was prepared and distributed. A regional conference, with proceedings, was also held for Eastern and Mid-Western Bargaining Associations at the University of Illinois in August 1959.

Plans: The work on grower payment methods involves an analysis of returns and price variability to growers of selected crops from various grower payment plans; and collection and analysis of data on the impact of bargaining associations will be undertaken. Publications are planned for each area of study.

Publications: Pooling and Other Grower Payment Methods as Used by Local Fruit, Vegetable and Tree Nut Cooperatives. Clyde B. Markeson, FCS General Report 67, October 1959.

Bargaining Cooperatives Pay Off. USDA Agricultural Research, Mar. 1959.

Interest Grows in Fruit and Vegetable Bargaining Cooperatives, Wendell M. McMillan. News for Farmer Cooperatives, March 1959.

Bargaining Cooperatives: Their Place in Agriculture Tomorrow. Joseph G. Knapp, USDA. Proceedings American Cooperation, 1959.

G. Price, Supply and Consumption

16. PRICE, SUPPLY, DEMAND AND OUTLOOK ANALYSIS FOR VEGETABLES AEC

Problem: Delineating and evaluating the effect of factors which influence supply, demand and price of vegetables in both the short-run and long-run; compiling and maintaining statistical series on stocks, production, consumer income, consumption and prices; analyzing these data and preparing reports; and servicing requests for information.

Program: A continuing program involving frequent appraisals of the current and prospective situation for vegetables, involving less than 1 professional Federal man-year annually.

Progress: During the past year continuing appraisals were made of the current and prospective short-term situation relating to supply, demand, consumption and prices of fresh and processed vegetables, dry edible beans and dry field peas. Results were published in quarterly issues of the Vegetable Situation and the National Food Situation and brief statements were included in monthly issues of the Demand and Price Situation.

Date were summarized and an article published in the January 1959 issue of the Vegetable Situation on "Trend to Smaller Retail, Larger Institutional and Bulk Containers for Frozen Vegetables." The discussion points out that about three-fifths of the total pack of frozen vegetables is put up in retail size containers. Within the retail category, the proportion of the pack in the 12-ounce and larger packages generally declined while smaller packages, principally the 10-ounce package, have gained in relative importance. In the institutional and bulk category, the shift has been in the opposite direction. During the mid-1940's the small institutional size as a group (under 30 pounds) were about twice as important as the large sizes. In 1956, however, poundage in the large

institutional and bulk containers exceeded, for the first time, the pack in the smaller institutional sizes.

An analysis was made of monthly unloads of fresh vegetables and potatoes in twenty important markets for the period 1953-57. The findings were used in the preparation of an article, "Seasonal Variation in Supply of Fresh Vegetables and Potatoes," published in the April 1959 issue of the Vegetable Situation. The article notes the seasonal variation in overall supplies of fresh vegetables, with supplies in the spring and summer averaging a fourth larger than those in winter. However, heavy supplies of some items in a particular season tend to offset light supplies of other items. Thus, there is less seasonal variation in total supplies available in the different seasons than might be generally supposed. Supplies of melons, on the other hand, are highly seasonal. More than four-fifths of the annual volume of watermelons, and about two-thirds of the cantaloups are available in June, July and August.

An analysis was made and an article published, in the July 1959 issue of the Vegetable Situation, on "Trends in the Geographic Pattern of Production of Vegetables for Commercial Processing." The study points up the rapid expansion in total production during the last two decades, and the increasing importance of the West. Trends in the more important States are also examined.

The July issue of the Vegetable Situation also contains an article on "The Market for Vegetables, Potatoes and Sweetpotatoes in Public Schools," by William S. Hoofnagle and Kenneth E. Anderson, USDA Market Development Division.

A brief summary or background paper and bibliography, is being prepared of available information on Vegetable Consumption Trends and Patterns. The paper is primarily for the use of Federal-State extension people working with marketing agencies.

Plans: Continuing analyses and periodic reviews will be made of the market situation for fresh and processed vegetables. Basic statistical series will be maintained, revised and extended.

Publications: The Vegetable Situation. AMS, Washington, D. C. (Quarterly)

The National Food Situation, AMS, Washington, D. C. (Quarterly)

The Demand and Price Situation. AMS, Washington, D. C. (monthly)

